SCIENCE ABSTRACTS.

Section A.—PHYSICS.

FEBRUARY 1917.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

FEBRUARY 1917.

GENERAL PHYSICS.

89. *Condensation Pumps.* **I. Langmuir.** (Gen. El. Rev. 19. pp. 1060–1071, Dec., 1916.)—In a recent paper [Abs. 963 (1916)] a new form of mercury-vapour pump was described, characterised by its extreme speed and the high degree of vacuum attainable. Two new types are here described, one built wholly of glass and the other wholly of metal. In these pumps a blast of mercury vapour carries the gas into a condenser. This action is similar to that in a steam ejector or the Gaede diffusion pump [Abs. 1178 (1915)]. The method by which the gas is brought into the mercury-vapour blast in the condensation pump is, however, based on a new principle which is essentially different from that employed in the ejector or the Gaede diffusion pump. The action of the condensation pump depends primarily on the fact that all the atoms of mercury vapour striking a mercury-covered surface are condensed, practically none being reflected. It is for this reason that the term condensation pump is proposed. To obtain the full benefit of the high speed of these pumps it is necessary to use connecting tubing of very large size. Equations are given by which the effect on the speed of exhaustion produced by tubing of any given dimensions may be calculated. Some special pumps have been built to operate by a combination of the injector and condensation pump principles, so that very much higher exhaust pressures may be used. In this way it has been possible to operate a single mercury-vapour pump producing as high a vacuum as the ordinary type of condensation pump, but exhausting at a pressure of about 20 mm. of mercury. Further development work will, however, be necessary before these pumps become as satisfactory in operation as a condensation pump backed up by a mechanical pump. A. W.

90. *Precision in Chemical Weighing.* **W. N. Rae** and **J. Reilly.** (Chem. News, 114. pp. 187–189, Oct. 20, and pp. 200–203, Oct. 27, 1916.)—The authors discuss the following points to which attention must be paid in order that accurate weighings may be made: The requirements of the balance-room and the arrangement of the balances in it; the construction of the balance, the conditions necessary for accuracy and the factors on which the sensitiveness depends; procedure to be followed in weighing; Borda's method of weighing by tares; precautions to be taken where very great accuracy is required; the assay balance; micro-balances, and vacuum corrections. T. H. P.

91. *Precision Projection Plot.* **F. E. Wright.** (Washington Acad. Sci., J. 6. pp. 521–524, Sept. 19, 1916.)—For the solution of spherical triangles and of certain crystallographic-optical problems graphical methods are often used. These problems involve the angular relations between directions in space, and are best presented and solved by means either of a sphere or of some projection of the sphere such as the stereographic projection. Various projection nets are briefly discussed and then a description is given of an improved type. The latter is similar in principle to that adopted by Wülfing, Johannsen, and Noll, but its design and construction are different; it is built with special reference to precision and convenience. A metal stand supports an electric lamp which illuminates a disc of frosted plate-glass; this plate in turn supports an equatorial projection net, stereographic or angle (globular), printed on thick transparent celluloid. The two nets are 40 cm. in-diam. and were reduced photolithographically by the precision methods of the U.S. Geological Survey, the first from a carefully taken print of the Sigsbee projection net, the second from an accurate drawing 50 cm. in diam. of an angle (globular) projection net. On both these nets, either one of which may be used, the curves are at 1° intervals and are sufficiently separated (nearly 2·5 mm. on an average) that 0·1° can be read off without difficulty. The celluloid disc rests on the glass disc and by means of centring screws can be centred to the axis of rotation of the outer steel ring which runs in an accurately turned bearing and carries the tracing paper on which the measurements are plotted in the positions indicated by the underlying projection net. Experience has shown that the distortion of the stereographic projection has in certain instances an appreciable effect on the attainable accuracy, and that for most purposes of calculation and of projection of optical data the angle (globular) projection net is preferable. A. W.

92. *Torsion of Solid and Hollow Prisms and Cylinders.* **C. Batho.** (Engineering, 102. pp. 497–498, Nov. 24, and pp. 521–522, Dec. 1, 1916.)—In a paper read before the British Association in 1915, the author demonstrated that if any thin-walled cylinder or prism, either continuous-walled or of framework, is subjected to a twisting moment T, the total longitudinal shear S is given by the expression $S = Tl/2A$, where l is the length of the cylinder and A the area bounded by the contour of its cross-section (not the area of actual cross-section). The application of this to a framed structure was considered in detail. The present paper considers more closely the case of the thin-walled cylinder or prism having a continuous boundary, extends the method to solid and hollow sections, obtains approximate formulæ for the torsion of rolled structural sections, and criticises certain formulæ in general use for hollow sections. W. J. C.

93. *Strength of Webs of I-beams and Girders.* **H. F. Moore** and **W. M. Wilson.** (Univ. of Illinois, Bull. No. 86. [50 pp.], 1916.)—The tests were made upon six 12-in. I-beams and two 24-in. built-up girders. The results are given in a large number of curves and tables, for which the original must be consulted. The main result is that: (1) The measured strains in various parts of the six I-beams and two built-up girders agree closely with the strains as computed by the ordinary elastic theory if due allowance is made for the lateral strain (Poisson's ratio effect). (2) The deflection of the girders as measured and as computed by the ordinary elastic theory agrees closely when the deflection due to shear is considered. For short-span beams the deflection due to shear may be as much as 20 % of the total. L. H. W.

94. *The Partition of the Load in Riveted Joints.* **C. Batho.** (Frank Inst., J. 182. pp. 553–604, Nov., 1916. Mech. Eng. 38. pp. 455–456, Dec. 15, 1916).—The first part of the paper is theoretical, and the second experimental.

It is shown that a riveted joint may be considered as a statically indeterminate structure, and that a series of equations may be obtained for any joint by means of the Principle of Least Work, giving the loads carried by each of the rivets in terms of a quantity K, which depends upon the manner in which work is stored in, or by action of, the rivets. Experimentally it is shown that extensometer measurements on the outer surfaces of the cover plates of a riveted joint are sufficient for the determination of the mean stresses in the plates, and that the partition of the load among the rivets may be determined from such measurements.

The results obtained allow the general manner of partition of load in any riveted joint, in which there is no eccentricity of connection, to be estimated, and it is hoped that, when further experiments have given general laws for the value of K, it will be possible to predetermine the exact load that will be carried by each rivet. The practical value of this is obvious. L. H. W.

95. *Instability of the Pear-shaped Figure of Equilibrium.* **J. H. Jeans.** (Roy. Soc., Phil. Trans. 217. pp. 1–84, July 11, 1916.)—The author proved in a former paper [Abs. 978 (1915)] that the stability could be decided only by calculation of the figure to terms involving e^3, e being the parameter measuring the deviation from the critical Jacobean ellipsoid. This he does here, and finds that the pear-shaped figure is definitely unstable. Throughout both papers the critical Jacobean ellipsoid which bifurcates into the pear-shaped series of figures has been taken to be $f \equiv x^2/a^2 + y^2/b^2 + z^2/c^2 - 1 = 0$, while any adjacent figure, of equilibrium or not, may be taken as $f + \phi = 0$, where ϕ is a function of x, y, z, in which the coefficients are numerically small. For special values of ϕ this figure will be one of equilibrium. All possible figures of equilibrium, differing infinitesimally from $f = 0$ form a linear series, and ϕ is of the form $\phi = eP$, where P is a function of x, y, z, and e is a parameter so small that e^2 can be neglected. In the former paper it was shown that when e^2 is taken into account there must be supposed to be a doubly infinite series of figures of equilibrium. The general form of ϕ is $\phi = eP + e^2Q + \zeta Q_1$, where ζ is a second parameter of the same order as e^2, but capable of variation independently of e^2. The value of $\omega^2/2\pi\rho$ for this figure of equilibrium is greater by ζ than the value for the critical Jacobean. The possible figures of equilibrium may be thought of as lying inside a rectangle having the rectangular coordinates e, ζ. In this paper the value of ϕ as far as third-order terms is found to be of the form $\phi = eP + e^2Q + \zeta Q_1 + e^3(R + KP)$, where R is a new function of x, y, z, and K is a constant. K would then appear to be at our disposal, but detailed examination shows that K is always infinite except for a special value of ζ. For this value of ζ, K can be eliminated by a new choice of parameter. For other values of ζ the solutions are valid only if e^3K be small, and replacing e^3K by a new parameter e_1, the solution becomes $\phi = 0.P + 0.Q + e_1P$, and so returns to the original first-order solution. Thus, except for one special value of ζ, it is impossible to carry the linear series outside the second-order rectangle. In the previous paper [*loc. cit.*] the author showed reason to believe that Darwin had introduced a spurious equation of equilibrium. This equation required a special value $\zeta = -0{\cdot}015988e^2$, making ω^2 decrease as we pass along the series of pear-shaped figures, which, for this value of ζ, were found to be stable. But, according to the author's previous paper, there was no need to assume such special value of ζ, and the present investigation shows that with this value of ζ it is impossible to extend the series beyond second-order terms at all, the only value of ζ for which such extension is possible being shown to be $\zeta = +0{\cdot}007423e^2$. Thus ω^2 increases as we pass along the true linear series, so that the equilibrium of the pear-shaped figure is necessarily unstable. The author, in conclusion, argues that, in the light of our general knowledge of the subject, the demonstration of the instability of the pear-shaped figure leads us to contemplate, in planetary evolution, a series of processes very similar to what would be expected if the pear were stable, but occurring in more rapid sequence. The problem is no longer one of slow secular changes amenable to statical methods, but becomes a dynamical problem, involving collapse and explosion, and the rapidity suggested is such that there would be no difficulty in supposing a planet may have traversed such a cycle several times. G. W. DE T.

96. *Nature of the Collisions of Electrons with Gas Molecules.* **K. T. Compton** and **J. M. Benade.** (Phys. Rev. 8. pp. 449–464, Nov., 1916.)—The present paper is a study of the collisions between electrons and gas molecules, with the object of obtaining information regarding molecular and atomic structure, since the phenomena accompanying such collisions must be explicable in terms of the distribution of electric charges in the molecule and the resulting electromagnetic field. Only a few characteristics of such collisions have been established.

When electrons or α-particles are projected with high speeds into matter their paths occasionally bend through large angles, indicating that they have passed through regions of intense force. Experiments by Rutherford (Abs. 808 (1906)], Geiger [Abs. 1248 (1910)], Wilson, etc., interpreted by Rutherford's theory of single scattering, have indicated that each atom contains a charged nucleus of excessively small dimensions but of a mass practically equal to that of the atom. Rapidly-moving electrons or α-particles are not useful in investigating the conditions of the electrons surrounding the nucleus, since their great momentum carries them past such mobile obstacles without appreciable deflection. Slow-moving electrons may be deflected by the electrons surrounding the nucleus, and in consequence may give up to these electrons a part of their energy. The scattering, energy loss, and ionisation by slow-moving electrons is more complicated than in the case of high-speed particles, but the authors hope to gain additional knowledge of atomic structure thereby. Collisions of slow-moving electrons with molecules of the inert gases, helium, neon, etc., and of mercury-vapour are nearly or entirely elastic, while in the common gases the electrons lose a large portion of their energy at each collision according to Franck and Hertz, and their experiments show that it is impossible for an electron to ionise a gas molecule unless its velocity at impact exceeds that acquired by motion through the minimum ionising potential which is characteristic of the gas.

The purpose of the present investigation was to make direct measurements of the average number of collisions made by an electron while moving 1 cm. through the gas when the pressure is 1 mm. The general plan of the experiment was to project electrons with a definite velocity through a hole in a plate, so that they moved toward a second parallel plate against a retarding field which was insufficient to prevent their reaching the plate unless they collided on the way. From the relative numbers reaching the second plate at various distances from the first plate, the average number of collisions experienced per cm. of path by each electron can be easily calculated. Full experimental details are given, illustrated by diagrams and curves. In order to interpret the experiments it has been found necessary to suppose that: (1) An electron is not always stopped whenever it strikes the spherical region which is sometimes called the molecule, whence the authors conclude that the molecule, or its field of force, does not possess radial symmetry. (2) The energy lost by an electron in striking or passing a molecule is a function of the least distance between their paths and is shown to vary inversely as the tenth power of the distance in the case of nitrogen. (3) It is also shown theoretically that this loss of energy should be greatest in the case of heavy complex molecules, less in the case of light simple molecules, and very small in the case of monatomic molecules—thus accounting for the phenomena of elastic and inelastic impacts. (4) From the experimental data, assisted by theoretical considerations, the authors have been able to calculate the natural frequency of a nitrogen atom with a fair degree of accuracy. (5) There is no such thing as a definite collision between an electron and a gas molecule: the phenomena which have been thus accounted for must be explained as the results of deflections and losses of energy in amounts which depend on the distance between the electron and a molecule at their nearest approach. The results of this investigation have no bearing on the theory of ionisation of gases by elastic impact, but they render untenable the simple assumptions regarding collisions on which the theory of ionisation by inelastic impact was based. Yet the accuracy of the equation for inelastic impact must be accepted as being very nearly correct. The theory of ionisation may be reconciled with the present results by supposing that the average amount of energy lost by an electron in moving 1 cm. among the force-centres is the same as if it lost its entire energy at each impact with imaginary spheres of definite radii. The concept of a collision in the ionisation theories is, therefore, an artificial one, which is made to yield accurate results by arbitrarily ascribing to the molecules such dimensions as will make the calculated loss of energy equal to the actual loss of energy as an electron moves through the gas. H. H. Ho.

97. *A Nomenclature for "Resistance Derivatives."* **G. H. Bryan.** (Nature, 98. pp. 189–190, Nov. 9, 1916.)—The author remarks that it is evident from Bairstow's National Physical Laboratory papers that the motion of "resistance derivatives" is likely to play a permanent part in the experimental study of aeroplane motions, as well as in the theoretical rigid dynamics associated with them. It therefore becomes important to have a uniform nomenclature for these quantities which shall be independent of the choice of axes, and thus free from any possible ambiguity or source of difficulty. This the author develops, pointing out that since in the symbolic notations hitherto used the force component is always written first and the component of motion producing it comes after as a suffix, it is important for the same convention to be followed in the proposed nomenclature. The latter is constructed of four-lettered words by combining the first two letters of any one name with the first two of any other. H. H. Ho.

98. *The Problem of Surface-tension Alteration.* **A. Pockels.** (Phys. Zeits. 17. pp. 441–442, Oct. 1, 1916.)—When the surface tension of a liquid is anomalous, *i.e.* smaller than that of a freshly produced surface, then by the withdrawal of a wetted substance (strip of paper, piece of wood, heated

metal plate, etc.) the adjacent surface layer moves towards it and on re-immersion is repelled. With a normal surface a weaker movement takes place in the reverse sense [see Abs. 2 (1908)]. The author now describes a simple experiment to show that a decrease of surface tension, and in consequence an anomalous surface stream, can be brought about in water by adsorption of vapours at the liquid surface. From this it evidently follows that the atmosphere does not act quite like benzol vapour on the surface tension of water, for otherwise at the boundary layer (water-air) no normal surface movement would be given such as takes place with very old surfaces, if they be only protected by impurities. If the tension of the water surface be only lowered 1 % by gas adsorption, then a distinct attraction towards a wetted body at withdrawal would ensue. Air is therefore not adsorbed at a water surface to a noticeable extent. Stöckle and G. Meyer have previously established a diminution of the surface tension of mercury by gas adsorption. The author believes that from the above standpoint many of the conflicting results of previous authors may perhaps receive explanation. H. H. Ho.

99. *The Weather Map.* **N. Shaw.** (Nature, 98. pp. 286–287, Dec. 14, 1916. Review.)—This official publication of the Meteorological Office gives in handy form an introduction to modern meteorology in simple language, and leads up to the construction of synoptic weather charts covering a wide area from information received at a central office by telegraph from a number of stations distributed over the area. The charts show the distribution of pressure, wind, weather, and temperature, the first-named element being shown by isobaric lines, and the remainder by symbols or figures written on the chart at the position of each station. These charts are prepared at short intervals of time, and enable the trained weather forecaster to predict with considerable accuracy the weather likely to be experienced in the near future.

The sequence of weather is illustrated by two examples of severe gales over the British Isles. Reference is made to the upper air, and the important influence which the conditions there exercise upon surface conditions. The volume closes with a number of diagrams of isopleths showing both the normal diurnal and seasonal variations of temperature, humidity, pressure, rainfall, and wind at observatories of the office; and tables showing frequencies of occurrences of stated values of temperature, rainfall, and other climatic elements, and of river levels, for each month at stations representative of each of the principal theatres of war. R. C.

100. *Weather Forecasting in the United States.* (U.S. Weather Bureau [Publ. No. 583; 358 pp.], Washington, 1916.)—This monograph, prepared as the result of a suggestion of C. F. Marvin that some sort of manual covering existing knowledge of this subject should be compiled, gives in its chapters an account of the general rules and considerations that are taken as a guide in forecast work. No brief abstract would be of value and it is therefore only possible to indicate the scope of the work by referring to the chapters *serialim.* Chap. I, by C. F. Marvin, deals with general principles and theory of atmospheric motions. In Chap. II W. J. Humphreys also discusses the general circulation of the atmosphere, while in Chap. III A. J. Henry gives a preliminary statement of the problem of weather forecasting, and in the next discusses changes in atmospheric pressure as graphically shown on the auxiliary pressure-change charts of the Bureau, and their significance in forecasting. In the fifth chapter an attempt is made

to present in a very general way the observed association of weather phenomena with the different forms of *highs* and *lows* of the weather map and the changes due to a relative shifting of these *highs* and *lows* with respect to each other. Chaps. VI, VII, VIII, and IX are devoted to the forecasting of special phenomena of the weather, while Chaps. X, XI, and XII deal with the forecasting of what may be called the daily routine of wind and weather. The volume contains 199 illustrations and maps, as well as a glossary and a selected bibliographical list. L. H. W.

101. *Meteorological Observations during the Total Eclipse of the Sun on October* 10, 1912. **W. Knoche** and **J. Laub.** (Terrest. Magn. 21. pp. 117–144, Sept., 1916.)—Full observations of meteorological elements were made at Boä Vista in Brazil from Oct. 2 to Oct. 11, 1912, and the results obtained during the eclipse on Oct. 10 are compared with the average for the whole period. Unfortunately the sky was completely clouded, and rain fell throughout the eclipse, and the results are mainly of a negative or indefinite character. R. C.

102. *Variation of Latitude at Greenwich for* 1915. **F. Dyson.** (Roy. Astron. Soc., M.N. 76. p. 789, Oct., 1916.)—Preliminary values of the latitude variation for 1915 are given from reduction of the observations with the Cookson Floating Zenith Telescope. A diagram is given showing the variation from 1911 Sept. to 1915 Dec. C. P. B.

103. *Anomaly in Leiden Meridian Observations,* 1864–1868. **E. F. van de Sande Bakhuyzen** and **J. E. de Vos van Steenwijk.** (K. Akad. Amsterdam, Proc. 19. 2. pp. 345–359, 1916.)—In the course of a re-examination of the Leiden transit observations for complete reduction an anomaly has been found which is ascribed to the observers making an abnormal estimate of the time of transit over the middle thread, detectable both in day and night observations. C. P. B.

104. *Determination of Apex and Velocity of Solar Motion.* **C. D. Perrine.** (Astrophys. J. 44. pp. 103–116, Sept., 1916.)—The author has already called attention in a former paper on the residual radial velocities of stars of different spectral classes to the presence of larger and apparently systematic residuals in the regions at right angles to the axis of solar motion [Abs. 38 (1916)]. In order to follow up the inquiry the material has been discussed in detail separately for northern and southern stars, for the stars of various spectral types, and for stars of varying orders of proper motion. There are such differences between the results from the northern and southern stars as to lead to the belief that there are radical structural differences in the two regions. Different values of the positions of the apex and velocity are deduced from the several groupings, and the solar velocity appears to vary in both hemispheres with the galactic latitude of the apex. With the exception of stars of class G, the velocity of the solar motion from the small-proper-motion stars is consistently less for the northern than for the southern stars. In general it is concluded that the apparently systematic differences in the position of the apex and in the velocity of the solar motion strongly indicate, if they do not establish, variations of the general direction and velocity of motion of the stars themselves in different portions of our stellar system. If this variation of the solar apex is confirmed, it will become necessary to choose some position as a fundamental one, and it is suggested that this should be derived from a better knowledge of stellar motions and of the structure of the Milky Way. C. P. B.

105. *Occurrence of Lithium Line λ6708 in Sun-spot Spectra.* **A. S. King.** (Mt. Wilson Solar Observatory, Contrib. No. 122. Astrophys. J. 44. pp. 169–176, Oct., 1916.)—Under varying laboratory conditions the complex lithium line at λ6708 is found to appear either as an unsymmetrical doublet or as a triplet of variable separation; and again the side components of the triplet change into the ordinary reversal, with the central component still visible. All these three conditions may be produced in either the arc or furnace spectrum; at times the doublet and triplet may be present together in different parts of the arc. It is concluded that a line at this position which is often found in calcium and other spectra is probably always due to lithium. A strong line at this wave-length in sun-spot spectra agrees so closely with the lithium line as to leave little doubt that this substance is present, although it appears to be absent from the photospheric spectrum. The high intensity of the line at low furnace temperatures affords evidence of the low temperature of sun-spots. [See also Abs. 1274 (1913); 689 (1915).] C. P. B.

106. *Determination of Solar Apex from Binary Stars.* **Luplau-Jansen, Hertzsprung.** (Roy. Danish Acad., Proc., 1916. Nature, 98. p. 236, Nov. 23, 1916. Abstract.)—By application of the method devised by Brevais in 1843 to the study of 180 double-stars the solar apex is found to be 264·5°, +25·1, and the velocity 17·15 km./sec. C. P. B.

107. *Solar Prominences in* 1916. **J. Evershed.** (Kodaikanal Obsy. Bull. No. 52. Nature, 98. p. 277, Dec. 7, 1916. Abstract.)—A summary of prominences observed during the first half-year of 1916 is given, with curves showing the variation. Compared with the previous half-year (July–Dec. 1915), the prominence-areas show a decrease, and the prominence numbers an increase. Metallic prominences were observed in increasing numbers. Absorption markings in H_α light, attributed to prominences projected on the disc, were photographed on 147 days. C. P. B.

108. *Supposed Variation in Solar Rotation.* **R. E. De Lury.** (Astrophys. J. 44. pp. 198–199, Oct., 1916.)—The case of supposed variation in the solar rotation announced by H. H. Plaskett [Abs. 657 (1916)] is ascribed by De Lury to the effect of an overlapping spectrum of atmospheric haze. Records made with the same instrumental equipment show that, in general, high values of the rotation were obtained on brighter days, and low values on the hazier days, and selections of the values are given in illustration of the view. The rotation values at the greater wave-length, λ5900, are greater than those at the smaller wave-length, λ4230, the spectrum of haze being stronger relatively to the spectrum of the limb for smaller wave-lengths than for the greater wave-lengths. C. P. B.

109. *Planetary Motion in Relation to Einstein's Theory.* **W. de Sitter.** (K. Akad. Amsterdam, Proc. 19. 2. pp. 367–381, 1916.)—A development is given of Einstein's theory in relation to the gravitational field of the sun, planetary motion, and the motion of the moon. Whereas Einstein and Droste consider only the field *outside* the sun, the formulæ developed in the present paper can be used both inside and outside the sun if the strains and pressures caused by gravitation inside the sun be neglected. C. P. B.

110. *Search for Trans-Neptunian Planet.* **A. Borelly.** (Jour. des Observateurs, 1. No. 12. Nature, 98. p. 277, Dec. 7, 1916. Abstract.)—In consequence of the systematic search that has been made, hitherto without success,

for a possible trans-Neptunian planet, it is considered that if existent it cannot be brighter than 12 magnitude, and the author thinks search might be continued by aid of the photographic chart of the heavens, which includes stars down to 14 magnitude. The existence of certain comets is regarded as favourable to the existence of some planet outside the orbit of Neptune.
C. P. B.

111. *Focus of Auroral Streamers on August* 26, 1916. **C. C. Trowbridge.** (Science, 44. pp. 717–722, Nov. 17, 1916.)—The aurora, which was of unusual brilliance, was seen by the author from Prince Edward Island (46° 25′ N., 63° 7′ W.). The glow prevailed around the entire heavens, causing the earth to be illuminated without shadows. It appeared first dimly in the southern sky, but rapidly increased in intensity until the entire southern half of the vault of the heavens was pierced by pale greenish streamers. The portion of these near the zenith appeared to radiate from a focus, zenith distance 16° 54′, azimuth 22° 42′ E. of south. This position of the focus in the sky is very closely the same as that to which the lines of magnetic force through the place of observation point, and it is concluded that the auroral streamers lay along the lines of the earth's magnetic force at a height of about 65 miles above the surface, and the apparent focus was due to a perspective effect. The occurrence of the Aurora Borealis in the southern half of the sky, as on the present occasion, appears to be an unusual phenomenon. J. S. Di.

112. *Inequality in Period of Eclipsing Variable RZ Cassiopeiae.* **R. S. Dugan.** (Roy. Astron. Soc., M.N. 76. pp. 729–739, Oct., 1916.)—The paper is on similar lines to previous publications on the stars RT Persei and Z Draconis [Abs. 38 (1916)]. The work on RZ Cassiopeiae was taken up in 1911 with the object of obtaining evidence concerning the presence of a secondary minimum. A considerable number of observations have been secured, and these are discussed in conjunction with many others from various observers. The plot showing the results for length of period is very nearly a sine curve, with period of inequality of 5280 periods of light variation, and amplitude of 0·014 deg. There appear to be disagreements between the photometric and spectrographic results. [See next Abstract.] C. P. B.

113. *Photometry of Eclipsing Variable RZ Cassiopeiae.* **R. S. Dugan.** (Astrophys. J. 44. pp. 117–123, Sept., 1916.)—Observing at Princeton with a polarising photometer, 9792 measures have been made on this variable discovered and recognised as of the eclipsing type by Müller in 1906. The star is of spectrum type A. From the light-curve new eclipse elements are given, and a set of elements for the system. A secondary minimum is noted, with a loss of light of 0·06 mag. The period is slightly over 28d. 41m. [See Abs. 544 (1916).] C. P. B.

114. *Colours of Stars in Globular Clusters.* **H. Shapley.** (Nat. Acad. Sciences, Proc. 2. p. 525, 1916. Nature, 98. p. 257, Nov. 30, 1916. Abstract.)—As the stars in clusters of this type may be supposed to be practically at the same distance from the earth, their apparent magnitudes can be assumed as directly proportional to the total light emitted. In four clusters investigated it has been found that the average colour-index is greater for the brighter stars, or that greater redness is associated with high luminosity. C. P. B.

115. *Series of Silicon Lines in B-type Stars.* **F. Henroteau.** (Observatory, No. 507. pp. 510–511, Dec., 1916.)—Taking the wave-lengths of the silicon lines characteristic in the spectrum of certain B-type stars, an interesting

relationship is shown to exist between the various wave-lengths. These lines occur in doublets, and two of these will illustrate the system :

$$\left.\begin{array}{r}\lambda_1 = 3856{\cdot}2 \\ 3862{\cdot}8\end{array}\right\}\text{diff.} = 6{\cdot}6 = d_1$$

$$\left.\begin{array}{r}\lambda_2 = 4128{\cdot}1 \\ 4131{\cdot}09\end{array}\right\}\text{diff.} = 2{\cdot}84 = d_2.$$

Then it is found that $d_1\lambda_1^2 = 2d_2\lambda_2^2$. From the behaviour of other members of the series it appears likely that a general law applies, of the form $d_n\lambda_n^2 = md_2\lambda_2^2$, where m is a whole member. C. P. B.

116. *Mass-ratios in Binary Stars.* **G. van Biesbroeck.** (Astron. J., No. 694. Observatory, No. 507. p. 513, Dec., 1916. Abstract.)—Attention is drawn to the problem of determining the partition of the total mass between the two components of a binary star. It is not necessary to have an accurate determination of the orbit, as observations of position with respect to surrounding stars at three sufficiently distant epochs will determine the mass-ratio without ambiguity. Results of this kind are communicated for the four stars η Cassiopeiæ, 70 Ophiuchi, τ Cygni, 85 Pegasi, with the mass-ratios for each pair. A list of stars suited for further study is appended. C. P. B.

117. *Internal Motions in Spiral Nebula.* **A. van Maanen.** (Nat. Acad. Sciences, Proc. 2. p. 386, 1916. Observatory, No. 507. pp. 514–515, Dec., 1916. Abstract.)—Comparisons have been made of the images of the spiral nebula M. 101 on four photographs taken between 1899 and 1915. Consistent measurements of the movements of certain selected points and condensations were made, showing the motion to be *outwards* along the arms of the spiral. If this be interpreted as a rotation, this is towards the concave sides of the arms. So that, although the outer parts appear to revolve more slowly than the inner parts, they are actually in advance of the inner parts, as if the spiral were unwinding itself. The period of revolution at 5′ of arc from the centre is found to be only 85,000 years. C. P. B.

118. *Variable Nebula. N.G.C.* 2261. **E. P. Hubble.** (Astrophys. J. 44. pp. 190–197, Oct., 1916.)—Photographs of this nebula obtained with the 24-in. reflector at the Yerkes Observatory have been examined with the blink-microscope, and distinct evidence of variability detected. The nebula as photographed is of cometary form, well defined, approximately an equilateral triangle with a sharp stellar nucleus at the extreme southern point, and fainter extensions from the northern portion. Comparisons made with other photographs, one taken by Isaac Roberts at Starfield on Jan. 27, 1900, and another by H. D. Curtis at Lick on Jan. 31, 1913, also confirmed the variations. It is interesting to note that the nucleus of this nebula has long been known as the variable star, R Monocerotis, having a light-range from 9·5 to 13 magnitude. Photographs are given showing the nature of the changes observed. C. P. B.

119. *Spectra of Nebula round ρ Ophiuchi.* **V. M. Slipher.** (Popular Astronomy, 24. p. 542, 1916. Nature, 98. p. 236, Nov. 23, 1916. Abstract.)—A photograph of the spectrum of the nebula round the star ρ Ophiuchi was obtained at the Lowell Observatory with a single-prism spectrograph, the total exposure on four nights being 20 hours. The spectrum was continuous, being similar to that of the star, and the author thinks this indicates that the nebula shines by reflected light. C. P. B.

LIGHT.

120. *Change of Absorption in Pleochroic Crystals at Low Temperatures.* **H. Nagaoka.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 551–554, Oct., 1916.)—The usual explanation of pleochroism rests on the assumption that electric conductivity in crystals is not the same in all directions. Theory shows that a variation of absorption with temperature is to be expected as a consequence of the temperature variation of conductivity. The temperature coefficient of conductivity is large compared with that for the index of refraction, so that any change in absorption must be largely due to that in conductivity. The well-known conductivity variation of crystals leads, then, to the conclusion that a decrease of absorption may be expected if the substance be cooled, and this decrease may differ with direction in pleochroic crystals. To test this conclusion, two similar Dewar vessels were placed side by side in a trough made of plate-glass. The trough and one of the vessels were filled with water and the other vessel with filtered liquid air. Pleochroic crystals from the same sample were placed in the two vessels and examined with a Haidinger's dichroscope by means of transmitted light. The crystals of pennin [$H_8(Mg, Fe)_5Al_2Si_3O_{18}$; $a : b : c = 0{\cdot}577 : 1 : 2{\cdot}277$] show a remarkable change, the decrease in absorption being apparent without the use of the dichroscope. The brownish-yellow tint with transmitted light gradually changes into light yellow if a thin slice of the crystal is dipped into the liquid air. The effect on the dark greenish tint, observed in the direction perpendicular to the brownish side, is not so clearly brought out, but there is an apparent diminution of absorption, the transmitted light changing from green to greenish blue. The epidotes [$H_2Ca_4(AlFe)_6Si_6O_{26}$; $a : b : c = 1{\cdot}579 : 1 : 1{\cdot}804$] also show similar diminution of absorption, but the change in tint is not so characteristic as for pennin. Brazilian tourmaline of greenish hue and also emerald was tested, but the results were not so well marked as for epidotes. A discussion of the results leads to the view that absorption is possibly due to sudden changes in the vibratory motions due to molecular impacts, by which the forced vibrations gradually decay into vibrations and translatory motions corresponding to the temperature of the substance, the amount of transmitted light being thereby diminished. This dynamical consideration harmonises with experiments on conduction and absorption. In pleochroic crystals the molecular impacts will be more frequent in one direction than in another on account of the arrangement of the molecules in their space-lattice, giving rise to the characteristic absorption here discussed. A. W.

121. *Workshop Method of determining the Refractive Index of a Block of Glass, of which only one Face is Polished.* **R. S. Clay.** (Engineering, 102. p. 621, Dec. 22, 1916. Paper read before the Optical Soc.).—The method is based, like that of the Abbe and Pulfrich refractometers, upon the determination of the critical angle when light passes from the medium of which the refractive index is to be found into a medium of which the index is known. The hemisphere of Abbe's, or cube of Pulfrich's, refractometer is replaced by an isosceles right-angled prism. The prism must, of course, have a higher refractive index than the substance to be measured. A simple telescope, composed of two spectacle lenses with a cross-wire at their common focal plane, is used to take the readings. A drop of liquid of high refractive index (such as quinoline or oil of cassia) is placed on the hypotenuse face of the prism, and this face is then placed upon the polished face of the glass of which the index is required. Sodium light is caused to fall on one side of the glass block, and the light emerging from one face of the prism is received by the telescope, which is turned until the critical angle is reached, shown by one half of the field becoming black, the dividing line being on the cross-wires. The observation is repeated for light falling on the opposite face of the glass block, and emerging from the other face of the prism. From the angle between the two positions of the telescope the refractive index of the glass is found by a simple calculation, or the scale can be divided to give the index directly. If the scale reads degrees, a curve can be drawn to give the index when the angle is known. If only rough readings are wanted, a scale can be constructed experimentally by observing the angle between the two telescope positions for four or five glass specimens of known index. Even in this way, the third decimal can be found correct to within a unit or two. In making the telescope, which can be of about unit magnification, the eye ring should be arranged to be conjugate to the prism, *i.e.* the eye is to be placed some distance beyond the Ramsden circle.

A. E.

122. *Refractometry and Identification of Glass Specimens, especially Lenses.* **L. C. Martin.** (Engineering, 102. p. 621, Dec. 22, 1916. Paper read before the Optical Soc.).—Usual methods for determining refractive index require at least one plane polished surface in the specimen, but the method described can be used for lenticular, irregular, or unpolished pieces of glass. By immersing the specimen in a liquid of equal refractive index the system becomes optically homogeneous for light of a particular wave-length. The liquid, which may be a mixture of carbon disulphide and alcohol, or a solution of mercuric potassium iodide, is contained in a hollow glass prism with plane parallel sides placed on the table of a spectrometer. The liquid is kept mechanically stirred. Spectra from the usual sources are observed by refraction through the prism. The introduction of the specimen diffuses the light, but any particular spectrum line may be focused by adjustment of the strength of the liquid. The refractive index of the liquid and specimen is then found in the usual way. Advantages of the method are its simplicity and its availability for direct measurement on light from a hydrogen vacuum tube. Defects in prisms for binoculars, etc., are very easily observed before polishing, by immersion in such a liquid. [See Abs. 1838 (1916).] A. E.

123. *Birefractive Colloidal Solutions.* **W. Reinders.** (K. Akad. Amsterdam, Proc. 19. pp. 189–197, 1916.)—With reference to the birefringency and resemblance to crystalline liquids exhibited by colloidal solutions of vanadium pentoxide under certain conditions [see Diesselhorst and Freundlich, Abs. 671 (1916); Kruyt, Abs. 1119 (1916)], no doubt exists as to the form of the particles or their direction by external forces. It has not, however, been decided whether the particles themselves are anisotropic, *i.e.* minute crystals, or whether they are isotropic and the double refraction consequently explainable by the unequal elasticity in different directions of the solution as a homogeneous whole.

The author finds that, in the freshly prepared vanadium pentoxide sol, the ultra-microns do not exhibit a one-sided growth and long needles are lacking. When the sol is heated, needle-shaped ultra-microns are formed in visible number and size increasing with the period of heating. The phenomenon of double refraction is very slight with the sol one day old, but it gets stronger on heating. The viscosity of the solution increases with the period of heating, and finally there are formed quite transparent, somewhat gelatinous lumps, which redissolve on dilution.

The peculiar silky lustre shown by old vanadium pentoxide sols on stirring is observed also in the formation of different crystalline precipitates and various suspensions, *e.g.* of barium sulphate, barium silico-fluoride, strontium sulphate, mica, kaolin, soap, mercurous chloride, and lead iodide, were tested as to double refraction. The last two give positive results, provided that the precipitate is very finely divided and does not deposit, so that the suspension has a colloidal character ; this condition was attained by allowing the precipitate to form in very dilute solution and in presence of a protective colloid. In these cases the double refraction is due to the crystalline structure of the ultra-microns, and, by analogy, it is probable that the ultra-microns of the vanadium pentoxide sol must be regarded as micro-crystalline.
T. H. P.

124. *Photoelectric Photometry.* **J. Kunz.** (Frank. Inst., J. 182. pp. 693–696, Nov., 1916.)—Discusses the relation between the intensity of light and the photoelectric current provoked by it with a view to deciding between the linear relation announced by Elster, Geitel, and Richtmeyer, and the non-linear relations found by Griffith, Lenard, and Ives. Three methods of varying the light were used : Nicol prism, rotating disc, and variation of distance ; and two methods of measuring the current : galvanometer and electrometer. The results gave a practically linear relation until the higher intensities of light were reached, when the current fell short by 1 or 2 %. No absolute values of the light intensity are given, but it is stated that the light was varied in the ratio 1 : 36.
E. E. F.

125. *Granules in Photographic Plates.* **P. P. Koch** and **G. du Prel.** (Phys. Zeits. 17. pp. 536–540, Nov. 1, 1916.)—A microscopic investigation of the condition of granules of silver bromide in various dry plates and the effect of illumination, development and fixing. There is generally a change of form on development. Some developers make fine-grained negatives ; they develop only a part of the AgBr granule (paraphenyldiamine developers and, to a less extent, metol-hydrokinone). There is no general law that the coarsest-grained emulsions are the most sensitive to light : in particular cases the result is the reverse of this.
A. D.

126. *Photography : Tone Reproduction and its Limitations.* **F. F. Renwick.** (Phot. J. 56. pp. 222–239, Nov., 1916.)—Discussion of the characteristic curves, as regards gradation of contrast, of various photographic material (positive and negative) and the reciprocal influence of these in relation to the tone-values of the finished print as compared with those of the original subject. Only subjects of limited range of contrast are within the bounds of scientifically correct tone-reproduction. Discusses also the relation between photometric gradation and the apparent gradation as seen by the eye under different conditions, and concludes that the more exactly the tonal relationships of the print are proportional to the true physical relations between them in the original the more truthful the result will be : but there are exceptions to this, and in some ways the failures of photographic materials can be turned to account for the more artistic rendering of the subject as the eye sees it.
A. D.

127. *Photography: The Sury Powder Process.* (Phot. J. 56. pp. 239–240; Disc., 240–243, Nov., 1916.)—An account of a pigmenting powder process for prints suitable for either monochrome or colour effects. A. D.

128. *Minimum Radiation Visually Perceptible.* **H. E. Ives.** (Astrophys. J. 44. pp. 124–127, Sept., 1916.)—A revised calculation is made of the minimum radiation visible to the eye in similar manner to that given by Drude ("Lehrbuch der Optik," 2nd Ed. p. 471). It is based on the assumption that this quantity is about that emitted by a sixth magnitude star, and that the pupillary aperture is about 6 mm. during night observation. In the transformation from star-light, generally white, to the standard Hefner lamp, which is comparatively reddish, account must be taken of this difference in effective visual energy. Russell's value of stellar-magnitude energy equivalents are used, and the radiation from a sixth magnitude star entering a 6-mm. pupil is given as $0{\cdot}38 \times 10^{-8}$ erg. per sec. per cm.^{2} C. P. B.

129. *Quantitative Absorption of Light by Simple Inorganic Substances. I. The Haloids of the Alkali Metals and Hydrogen.* **P. J. Brannigan** and **A. K. Macbeth** (Chem. Soc., Trans. 109. pp. 1277–1286, Nov., 1916.)—In this investigation a Hilger sector photometer, with a high-tension spark source were used in conjunction with an ultra-violet spectroscope, and allowed molecular extinctions to be measured. The alkali haloids are shown to possess selective absorption in the ultra-violet region, and the frequency of the band decreases with increase of atomic weight of the halogen radical. The hypothesis is advanced that the bands are due to vibrations in the halogen ion induced by the metallic radical and, as in the case of fluorine, these vibrations probably extend beyond the present limits of examination. The molecular extinction-coefficient of the alkali haloids is shown to increase with increase of atomic weight of the metals and notably in the case of iodides. Bromides do not show this phenomenon and the behaviour of lithium is abnormal. C. S. G.

130. *Pole-effect in Calcium Arc.* **W. T. Whitney.** (Astrophys. J. 44. pp. 65–75, Sept., 1916.)—Investigators of the iron arc-spectrum have found various systematic displacements in the lines characteristic of the "pole spectrum," as distinguished from the spectrum of the core of the arc [Abs. 1829 (1914); 691 (1915)]. The present paper gives the results of a similar examination of the pole-effect in the arc spectrum of calcium, from plates taken with a 20-ft. Rowland concave grating, giving a dispersion of 1·32 Å. per mm. Tables are given showing the pole-effect for series and non-series lines. It is concluded that in general the phenomenon depends upon the existence of an intensity gradient along the arc, thus strengthening the hypothesis that the amplitude of vibration of the electrons is the determining factor. C. P. B.

131. *Spectroscopic Resolving Power.* **C. M. Sparrow.** (Astrophys. J. 44. pp. 76–86, Sept., 1916.)—An experimental determination of the actual resolving power of a perfect grating or prism has been made by photographic and visual examination of the images of a series of screens cut as templates to the intensity curves of two lines very close together. For equal intensities of the two lines it is found that the limit of resolution is given when the central minimum just disappears, giving the condition termed by the author the "undulation condition." This gives a theoretical resolving power about 26 % greater than that obtained by the Rayleigh criterion. This limit also holds for unsymmetrical doublets when the ratio of intensities of the components is less than 10 to 8. The effect of slit-width and absorption can be introduced by suitable factors. An approximate formula is also given for the resolving power of the Fabry and Perot interferometer. C. P. B.

132. *Structure of the Atom-core (the Spectra of Hydrogen and Helium).* **J. Ishiwara.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 540–550, Oct., 1916.)—A mathematical discussion of the spectra of hydrogen and helium, based on Bohr's atom-model theory.

The paper does not permit of a short abstract. A. B. W.

133. *Influence of an Electric Field on the Light Transmitted and Dispersed by Clouds.* **C. M. Hoogenboom.** (K. Akad. Amsterdam, Proc. 19. 2. pp. 415–432, 1916.)—The research here described is a continuation of the experiments of Zeeman and Hoogenboom [Abs. 662 (1912)]. The work deals with the double refraction which some clouds (especially of ammonium chloride) show in an electric field, and with the influence of the electric field on the intensity of the transmitted and the dispersed light. Measurements of the double refraction were made in fields up to 3500 volts. The graphs thus obtained are similar in general appearance to the magnetisation curve for iron, showing a point of inflection below about 200 volts, and indicating an asymptotic approach to a max. value of the double refraction for the higher voltages employed. As regards dispersion in the double refraction, no definite result was obtained with the α-modification of NH_4Cl, but the β-modification gave positive results, which indicate that the rays with the greatest index of refraction show the smallest double refraction—a result which is in contradiction with all that has been found hitherto with reference to the Kerr-effect. Similar results were obtained with clouds of indigotine, NH_4Br, and NH_4I. Further experiments indicated a distinct dichroism in NH_4Cl clouds, and it was found that the difference in absorption for vibrations parallel and perpendicular to the field increases when the wave-length decreases. Possible explanations of the phenomena are suggested. A. W.

134. *Effect of Electric Field on Spectrum Lines of Calcium and Lithium.* **J. T. Howell.** (Mt. Wilson Solar Observatory, Contrib. No. 121. Astrophys. J. 44. pp. 87–102, Sept., 1916.)—Results are tabulated for the transverse and longitudinal effects of calcium and lithium in fields of 20,000 volts/cm., showing different values from those given by previous investigators. The longitudinal effect in lithium gives clearly polarised components, whereas all the longitudinal components in hydrogen and helium have been unpolarised. The H and K lines of calcium show an unexpected separation comparable with that of the lines of H, He, and Li; this is surprising considering the high atomic weight of Ca, and the fact that the H and K lines do not belong to a diffuse series. [See Abs. 666 and 667 (1914).] C. P. B.

135. *Colour Photographs of the Phosphorescence of Certain Metallic Sulphides.* **E. L. Nichols.** (Am. Phil. Soc., Proc. 55. pp. 494–502, 1916.)—Variations in the brightness and colour of phosphorescence with time, temperature, etc., have been investigated by Lenard [Abs. 810 (1910)] and others, but some of the variations are so rapid and so varied in character that it seemed of interest to attempt to record them by means of colour photographs. To this end a special form of phosphoroscope was constructed, by means of which the substance, enclosed in a flat glass tube about 10 cm. long and from 1·0 to 1·5 cm. wide, was viewed through a revolving disc with alternate open and closed

sectors of 45° aperture. The disc was mounted on the shaft of an a.c. synchronous motor on a 60-cycle circuit, and the substance in the tube was excited by a series of five sparks in line between zinc terminals. A four-armed wheel of zinc mounted on the motor shaft was arranged so that its arms passed the two terminals of the sparking circuit with an air space of about 1 mm., and the sectored disc was adjusted until the sparks occurred when a closed sector obscured from view both the sparks and the substance under investigation. Thus the substance was intensely illuminated 120 times a second, and was visible during intermediate intervals of 1/240 sec., each beginning about 0·0001 sec. after excitation ceased. For observations during later stages of decay the wheel could be driven slowly by means of a d.c. motor, or moved stepwise an eighth of a revolution at a time at the desired rate. The tube was mounted within a cylindrical Dewar flask with unsilvered walls. The lower end rested in a metal mercury-cup from which a copper rod projected downwards into liquid air. The upper end passed through a heating coil. Thus a temperature gradient was established from about −185° C. to +20° C. or higher, and in this way the colours of phosphorescence through the entire range could be observed and photographically recorded. In the case of one sulphide (Ba, Cu, $Na_2B_4O_7$) the initial tint of red-yellow changes with time to a deep red. Another preparation (Ca, Bi, Na_2SO_4; $CaF_2Na_2B_4O_7$), which is typical of many, appears bluish green through the rapidly revolving disc, and changes very rapidly after the close of excitation to a deep violet. The work of Lenard and others has shown the spectra of these substances to consist of broad overlapping bands, and it is clear that in these two examples two or more such bands are concerned. In the first of the two examples the band of shorter wave-length decays much more rapidly than that of longer wave-length, and the colour at any time after excitation is the sum of the instantaneous values of the two components. All barium sulphides studied show similar effects, the green band decaying very rapidly and the red band more slowly. The Ca and Sr sulphides show an opposite effect, the green band being of shorter duration than the blue or violet band. The slow bands are greatly diminished in intensity by cooling, and are often reduced almost or quite to the vanishing-point. In this way the colour and intensity of the rapid band may be observed by itself. Thus, for the Ba-Cu sulphide already mentioned, the red-yellow of the warm end of the tube merges gradually into a brilliant green (about −70° C.). A second red-yellow patch occurs still lower down (about −160° C.), while at the very bottom (about −185° C.) there is a return to green. The effect of cooling the phosphorescent sulphides of Ca and Sr is analogous, the short-period green band persisting at low temperatures. A. W.

136. *Secondary Action of X-rays.* **F. Voltz.** (Phys. Zeits. 17. pp. 532–536, Nov. 1, 1916.)—An examination and discussion of points arising out of an earlier paper on "Photographic methods of measuring the hardness of X-rays" [see Abs. 1767 (1915)]. It is found that some of the peculiarities previously observed, especially in connection with the use of photographic films of different kinds, are explained on a consideration of the selective absorptive powers of the emulsions. A. B. W.

137. *Variation of the Coefficient of Emission of the Secondary-radiation with the Wave-length of the Exciting X-rays.* **R. Glocker.** (Phys. Zeits. 17. pp. 488–490, Oct. 15, 1916.)—In these experiments exciting X-radiation of the following wave-lengths was employed: (1) Iron, $\lambda_A = 1·759 \times 10^{-8}$ cm.; (2) chromium, $\lambda_A = 2·097 \times 10^{-8}$ cm.; (3) copper, $\lambda_A = 1·386 \times 10^{-8}$ cm. The radiators

used were Ni, Cu, Sn, Zn, As, Se, Sr, Mo, Ag. The law of variation of the coefficient of emission, K, with the exciting wave-length, λ, for the group of elements Cr to Cu, is found to be represented by $K = A(\lambda/\lambda_A)^4$, where A is a constant characteristic of the element radiated, λ the wave-length of the exciting radiation, and λ_A the wave-length of the characteristic secondary radiation. A. B. W.

138. *The K Absorption Band of the Elements, from Bromine to Bismuth, and the Emission from a Coolidge Tube.* **M. de Broglie.** (Comptes Rendus, 163. pp. 87–90, July 24, 1916.)—Making use of his own method [Abs. 1887 (1914)] the author gives a table of the angular positions of the absorption bands of the elements from Br to Bi. The tube used had a tungsten kathode, so that in the case of the elements Pt, Au, Hg, Tl, Pb, Bi, Th, the atomic weight of the screen was greater than that of the antikathode. He then states, with reference to the doublet in the K group of tungsten [see Abs. 894 (1916)], that close to this doublet, in the direction of shorter wave-lengths, there is an intense emission found which is prolonged as far as the most penetrating rays given off by the tube; this leads to the idea that an element, when used as antikathode, gives off a continuous spectrum in the spectral region corresponding to its absorption band. There are thus present, in the radiation given off by a tube, rays of considerably greater penetration than the K-rays of its antikathode.

The author points out that the absorption bands provide another means of attacking the problem of Planck's relation $eV = h\nu$. L. H. W.

RADIO-ACTIVITY.

139. *Distribution of the Active Deposit of Radium in an Electric Field.* II. **G. H. Henderson.** (Nova Scotian Inst. of Science, Proc. 14. No. 2. pp. 123–132, 1915–1916.)—The experiments described in this paper were suggested by the results of a previous investigation of the analogous problem for thorium [Abs. 448 (1916)]. After criticising the results of Eckmann (Jahrb. d. Radioaktivität, May, 1912) and Walmsley [Abs. 811 (1915)], the author outlines the more reliable method employed by Wellisch [Abs. 249 (1914), 568 (1915)]. As a result of the present research the following conclusions are given:—"(*a*) In atmospheres of air, hydrogen, CO_2, etc., all the rest-atoms (the active deposit particles) of radium appear to be initially positively charged. (*b*) So far no gas or vapour has been discovered in which the radium rest-atoms are not all similarly charged. In this respect the behaviour of the rest-atoms of radium is the same as that of the rest-atoms of thorium." A. B. W.

HEAT.

140. *Freezing-point of Mercury.* **R. M. Wilhelm.** (Bureau of Standards, Bull. 13. pp. 655–661 [Sci. Papers, No. 294], 1916.)—The freezing-point of mercury was determined by means of resistance thermometers calibrated at 0°, 100°, and the sulphur boiling-point (444·6° at normal pressure). Various precautions were observed to avoid errors due to impurities in the mercury, conduction along the leads, and the heating effect on the thermometers of the measuring current. The mean value — 38·878° C. was obtained for the freezing-point, the max. deviation of any determination from the mean being 0·005 deg. Previous values for the same point are summarised below.

Authority.	Date.	Thermometer.	Value.
Hutchins	1776		— 39·44° C.
Cavendish	1783		— 39·38
Regnault	1862		— 38·50
B. Stewart	1863	Gas thermometer	— 38·85
Vicentini and Omodei	1888	Mercury thermometer previously compared with the gas thermometer	— 38·80
Chappius	1896		— 38·85
Chree	1898		— 38·86
Henning	1914	Platinum thermometer	— 38·89

E. G.

141. *Convection Currents in a Horizontal Layer of Fluid, when the Higher Temperature is on the Under Side.* **Rayleigh.** (Phil. Mag. 32. pp. 529–546, Dec., 1916.)—Gives the theory of some experiments by Bénard [see Abs. 1815 (1900)] on thin layers of liquid on a levelled metallic plate maintained at a uniform temperature, the upper surface being usually free and at a lower temperature. The layer was found rapidly to resolve itself into a series of cells, two phases being distinguished. In the first of these the cells were nearly regular polygons of 4 to 7 sides. In the second there was a tendency to a limit of regular hexagonal cells.

The theory is concerned solely with the former of these two phases. The case is somewhat related to that of a cylindrical rod of elastic material under a longitudinal compression sufficient to overbalance its stiffness, or to that of a cylinder of fluid disintegrating under the operation of capillary force. There is nothing in the theory to fix the *phase* of the predominant disturbance, and this indeterminateness is connected with the circumstance that absolute regularity is not to be expected.

The Bénard problem is exceedingly complicated unless it be arbitrarily limited to two dimensions. The cells of Bénard are then reduced to infinitely long strips, and when there is instability it may be asked for what wave-length (width of strip) the instability is greatest. The answer can be given under certain restrictions, and the manner in which equilibrium breaks down is then approximately determined. The calculations are based upon equations given by Boussinesq. The special limitation which characterises them is the neglect of variations of density, except in so far as they modify the action of gravity. It appears, a little unexpectedly, that the equilibrium may be thoroughly stable (with higher temperature below) if the coefficients of conductivity and viscosity are not too small.

An appendix deals with a related problem having various physical interpretations, such as the symmetrical vibration in two dimensions of a layer of air enclosed by a nearly circular wall. T. B.

142. *The Vapour Pressure of Zinc, Cadmium, and Mercury.* **A. G. Egerton.** (Phil. Mag. 33. pp. 33–48, Jan., 1917.)—The method employed is based upon that of Knudsen [Abs. 1068 (1909)], whose apparatus consisted of a glass tube with thin glass partition containing a small aperture. One end of the tube is kept at a constant temperature while the other is cooled, and the weight G of vapour condensed in time T is measured. The difference of pressure of the mercury in the two compartments is then given by $p - p' = (w_1 + w_2)G\rho^{\frac{1}{2}}/T$, where ρ is the density of the vapour and w_1 and w_2 are the resistances offered to the passage of the vapour by hole and tube respectively. The method is improved and its scope widened by various contrivances, *e.g.* (1) several holes (circular) are employed; (2) quartz tubes are used, and the diaphragm may be of quartz, steel, or Pt; (3) the deposits are weighed instead of being (as in Knudsen's work) measured volumetrically; (4) very low vacua are obtained by the use of charcoal and liquid air. In this way pressures as low as 10^{-6} mm. of mercury can be measured. The results are extremely consistent as shown in diagrams in the original, where log p is plotted against the reciprocal of the absolute temperature. Other metals are to be investigated, and it is hoped that data may be obtained for the measurement of the force of cohesion and the law of attraction and repulsion between atoms. T. B.

143. *Spontaneous Ignition studied by Means of Photographic Plates.* **F. J. Hoxie.** (Am. Soc. Mech. Eng., J. 38. pp. 997–999, Dec., 1916.)—Dry cotton or fine soft-wood shavings ("excelsior") in sunlight in contact with atmospheric oxygen undergoes very slow burning, or oxidation, at the ordinary temperature of the air, the velocity of this oxidation depending on the temperature, moisture, light, and mineral or organic substances present. After exposure for several months to sunlight and atmospheric moisture to the extent of so-called "dampness," cotton cloth exhibits in some degree the charred appearance produced by contact with a hot iron for a few seconds. This action is accelerated by addition of certain catalysts, such as iron and manganese, capable of acting as oxygen-carriers and the temperature may be raised very considerably when the slowly burning substance is completely enclosed by heat-insulating material.

Curves have been prepared which show the rates at which the absorption of oxygen by cottonseed, linseed, and lard oils increases with rise of temperature. The form of these curves furnishes the most significant characteristics of substances subject to spontaneous ignition, as it shows the temperature at which the velocity of combustion commences to increase rapidly with rise of temperature.

It is shown that the hydrogen peroxide given off by substances undergoing spontaneous oxidation is able to produce a developable image on a photographic plate in the dark, and the intensity of this image appears to be about proportional to the velocity of oxidation. Oils subject to spontaneous ignition are particularly active in this respect. T. H. P.

144. ***Frequent Bursting of Hot-water Pipes in Household Plumbing Systems.*** **F. C. Brown.** (Phys. Rev. 8. pp. 500–508, Nov., 1916.)—It is a common

observation by plumbers that the pipes carrying the hot water from the furnace to the kitchen and bath-room burst from freezing far more frequently than the pipes carrying the cold water. Experiments have been made with glass tubes, the practical conditions being simulated as nearly as possible.

The results obtained confirm the above observation and show that the occluded air in tap-water is responsible for the delay or absence of bursting of the pipes. The air and accompanying impurities assist in furnishing nuclei of crystallisation so that the ordinary tap-water begins to freeze at the usual freezing-point. At the same time the ice formed is more mobile, especially near the middle of the tube, so that until very low temperatures are reached the pressure is released along the middle of the tube by the flow of water and ice. In addition the air-bubbles displacing water form cushions which also relieve the pressure on the tube to a certain extent. The presence in the water of dissolved salts has no special bearing on the phenomenon.

Water which had been previously boiled was found invariably to be undercooled several degrees below zero before freezing commenced, the temperature then remaining at zero from the commencement to the end of freezing; the ice formed was quite clear and solid. T. H. P.

145. *Counting the Degrees of Freedom in an Electronic Cloud.* **A. Landé.** (Ann. d. Physik, 50. 1. pp. 89–105, June 6, 1916.)—The first part of the paper deals with the various methods employed by Jeans, v. Laue, and others, for the analysis of the radiation within an isolated envelope, and is subdivided into two sections, the first being an application of the Fourier series and the second an investigation of the degrees of freedom of the isolated volume. In Part II of the paper the author shows how similar results are obtained by a method based upon the oscillations in the distribution of the spectral and volume energy. He asks whether all colours are really independent of each other owing to the continuous alteration in the distribution of energy in the spectrum, or whether a given colour defines a neighbouring colour at the same instant, *i.e.* whether intensity changes at neighbouring points are not connected in some manner at each instant. The author finds theoretically that with continuous alterations in volume and spectral intensity, two neighbouring points are the more dependent upon each other as regards space and spectrum the nearer they lie together, so that with any particular value there is a critical volume interval and a critical colour interval within which dependence exists, and without which rules freedom. The critical intervals are analogous to the critical limits of the harmonic and optical solutions both of which are also defined for any particular value. H. H. Ho.

146. *Thermodynamics of the "Throttling" Process.* **R. Plank.** (Phys. Zeits. 17. pp. 521–529, Nov. 1, 1916.)—In a former paper [Abs. 1075 (1915)] various relations were deduced between the Joule-Thomson effect, the specific heat and the equation of state. New equations are now given, the chief object of which is to show the relation existing between the elementary cooling effect $\alpha = (\partial T/\partial P)_i$ at absolute temperature T and pressure P, and the total cooling effect $\Delta = T - T_0$, due to throttling from P to P_0. It is shown that measurements of Δ at various temperatures and pressures are in general to be preferred to those of α in that the latter can always be deduced from the former, while the reverse process is not always possible. Again, the specific heat as well as the equation of state can be expressed far more conveniently in terms of Δ. A discussion follows on the precise definition of the "inversion curve," which is given by some writers in terms of the equation $\Delta = 0$; that is, by uniting those values of temperature and pressure starting from which no temperature-change occurs on throttling to atmospheric pressure. Others define the inversion curve by the equation $\alpha = 0$. The author recommends a distinction between the two curves by naming them respectively the "final inversion curve," and the "elementary inversion curve." Finally it is shown that the equations of Linde, Davis, and Grindley can be immediately developed from the fundamental equation of Thomson.

T. B.

147. *Kinetic Theory of Simple and Composite Monatomic Gases.* **S. Chapman.** (Roy. Soc., Proc. 93. pp. 1–20, Dec. 1, 1916.)—This paper summarises the work already published by the author on the kinetic theory of non-uniform monatomic gases [Abs. 794 (1916)], and also a paper, not yet published, dealing with mixtures of such gases. The new work follows the same lines as before. General expressions are obtained for the viscosity, diffusion, and the transfer of energy by conduction and by thermal and pressure diffusion. The results are then applied to particular molecular models, and numerical values are obtained for a number of special cases. The expression for the ordinary coefficient of diffusion of one gas into another gives, as a first approximation, the formula first obtained by Langevin which is exact only in the case of Maxwellian molecules (*i.e.* centres of force varying inversely as the fifth power of the distance). A second approximation is obtained by applying a correction factor which depends on the ratio of the numbers of the molecules of each gas present in unit volume. This factor is quite small, showing that the dependence of the diffusion coefficient on the relative concentration of the molecules is much less than that indicated by Meyer's formula even in the improved form given by Kuenen. The max. value of the factor is 1·132 for a mixture of rigid spherical molecules of which one kind are of negligibly small mass compared with the other. In all other cases it is less than this. The theoretical values are in reasonable agreement with experiments on the interfusion of various mixtures of argon and helium, and of oxygen and hydrogen. In connection with thermal diffusion it is shown that if, for example, argon and helium are originally present in equal proportions in two connected bulbs at 0° C. and one bulb is then raised to 100° C. and maintained there, the heavier gas will concentrate in the cold bulb in the ratio of 52 % to 48 %. The expressions for viscosity and thermal conduction in mixed gases are very complicated, and consideration of them is deferred. The last section of the paper deals with the difference in temperature between two component gases when the percentage ratio of the components is altering. It is shown that the equipartition of energy is disturbed only by a negligible amount even in an extreme case. D. O. W.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

148. *Electrical Phenomenon in Cloud-like Condensed Odorous Water-vapours.* **H. Zwaardemaker, H. R. Knoops, and M. W. van der Bijl.** (K. Akad. Amsterdam, Proc. 19. pp. 44–49, 1916.)—Gaule (1900) pointed out that odorous substances are often present in the air in the form of water vapours with a cloud-like condensation. The authors have investigated this phenomenon by means of Gradenigo's apparatus, with which use is made of a simple glass sprayer, of the adiabatic expansion of compressed air supplied under an over-pressure of 2 atmos., and of the splashing of the water-drops against a glass wall. The mechanism of the phenomenon is probably as follows. The rapid air-current draws up the water in which the substance to be examined has been dissolved. The water evaporates in the air which streams past and which has become ionised at the vertical nozzle and saturates the air with water-vapour, provided that excess of water is present. Meanwhile, the over-pressure being reduced to zero, the air suddenly expands, so that a considerable fall of temperature ensues and a cloud-like condensation appears. The spray splashes against the glass wall and, as stated by Gradenigo and Stefanini, what flies past it gives a cloud, which may be stored for a considerable period if the precaution has been taken to dissolve in the water a small percentage of common salt or of a mixture of salts. Even the most diverse non-volatile substances, electrolytes or non-electrolytes, when dissolved in water give beautiful dense clouds which may be stored for hours in a Tyndall case. With aqueous solutions of odorous substances, which are naturally more or less volatile, the cloud is less steady and disappears after some minutes.

When a simple condensed water-vapour or a salt-containing cloud is driven against a well-insulated metal plate connected with an electroscope, no charge is apparent. When, however, an odour-containing condensed vapour is allowed to flow, even from some distance, against a metal disc, a considerable charge is developed, this being always positive under the experimental conditions employed. All the true odorous solids examined were found to behave in this way. If the disc is replaced by wire gauze, the latter becomes positively charged, while the negative drops pass through it and may be caught on a disc behind; the positive drops streaming down the gauze emit a stronger scent than the negative ones collected on the disc.

Electrification is observed with very minute quantities of true odorous substances; for instance, 25×10^{-6} of geraniol taken up in 25 cm.^{3} of 2 % sodium salicylate solution is sufficient to produce a distinct charge, even although the 25 cm.^{3} of liquid becomes diffused through a large volume of air. The minuteness of the amount of substance thus manifesting itself appears to depend on the molecular weight, on the volatility, and on its effect in lowering the surface tension; these factors constitute the physical conditions which must be fulfilled by a substance acting biologically as an odorous substance. T. H. P.

149. *Specific Smell Intensity and Electrical Phenomenon of Cloud-like Condensed Water-vapours in Chemical Series.* **H. Zwaardemaker.** (K. Akad.

Amsterdam, Proc. 19. 2. pp. 834–840, 1916.)—From the correlation of the odoroscopic phenomenon previously described [see preceding Abs.] with molecular weight, volatility, and depression of the surface tension of the solvent, a relationship may be expected to exist between the smell intensity of a substance and the intensity of the electrical phenomenon. That such a relationship actually exists is shown for the homologous series of the simple aliphatic alcohols and acids. T. H. P.

150. *On the Origin of the Electricity of Precipitation.* **H. Geitel.** (Phys. Zeits. 17. pp. 455–464, Oct. 1, 1916.)—This is a report on the state of our knowledge of the subject of the origin of the positive and negative charges of electricity found in raindrops, snowflakes, and hailstones in different circumstances, with special reference to the conditions obtaining in thunderstorms and an account of modern theories of thunderstorms. R. C.

DISCHARGE AND OSCILLATIONS.

151. *Thermionic Currents from Molybdenum.* **E. R. Stoekle.** (Phys. Rev. 8. pp. 534–560, Nov., 1916.)—Measurements were made of the thermionic currents from a molybdenum wire to a concentric cylindrical anode, water-cooled to prevent the liberation of occluded gases at high temperatures. The author finds that "at pressures above 0·001 mm. the saturation thermionic currents obey Richardson's equation ($i = AT^{1/2}\epsilon^{-b/T}$ when i is the current and T the absolute temperature of the metal) with the values of the constants $A = 5 \times 10^{11}$, $b = 8{\cdot}1 \times 10^4$." The current at these pressures is not a pure electron current, as is shown by its failure to satisfy the theoretical relation between current and anode potential. A visible coating of molybdenum oxide increases the electron emission from the metal above that of a clean surface. The oxide coating volatilises or decomposes at about 1400° C., and with its disappearance the electron emission decreases.

At a pressure of the order 5×10^{-6} mm. the electron currents are shown to follow the theoretical relation between current and voltage up to 280 volts and 0·06 amp. per cm. length of wire. From the curves, values of e/m are calculated, and agree well with the generally accepted value. Before this pure electron emission is obtained the filament must be heated and the anode subjected to electron bombardment a number of times, during which treatment it was found that the thermionic current decayed at the high voltages and recovered at the lower voltages. This effect is attributed to the liberation of gases from the anode by the more intense electron bombardment to which it is subjected at the high voltages and to the ionisation of the gases thus liberated and their consequent accumulation near the surface of the hot kathode. When the voltage is lowered these gases are driven from the filament because of its high temperature, and so the electron emission increases. Because of the observed increase of current by a film of oxide it is not thought that the gases form a chemical compound on the filament surface, but rather that they create an electrical potential which hinders the escape of the electrons.

The saturation currents were studied as a function of the filament temperature at pressures of the order 5×10^{-6} mm. The initial behaviour of a clean wire is very irregular. In general the values of the constants A and b are larger than the values in the final condition. Above 2100° K., Richardson's equation is followed with $A = 1{\cdot}1 \times 10^6$, and $b = 5{\cdot}36 \times 10^4$. This characteristic emission persists when the temperature is again lowered, but on keeping the filament at a low temperature its emission decays down to that represented by the larger values of A and *b*. Again, this decay is attributed to adsorption of gas at the low temperature rather than to the formation of a chemical compound.

In accordance with the results of Wilson and Richardson on Pt and W, it is found that log A is a linear function of *b* when the values of A and *b* corresponding to different conditions of the molybdenum surface are plotted. Richardson's theory is applied to determine the contact potential of the contaminated surface and the pure metal. T. H.

152. *Comparison of Alternating- and Direct-current Spark Potentials.* **J. C. Jensen.** (Phys. Rev. 8. pp. 433–448, Nov., 1916.)—Experiments are described in which alternating- and direct-current spark potentials are measured under exactly the same conditions of gas, electrodes, and pressure. The application of the required voltages to the gap was controlled by a throw-over switch, enabling max. alternating or direct voltages up to 4000 volts to be connected to the gap. Oscillatory discharges were prevented by the inclusion of variable liquid resistances in the spark-circuit. The applied potential was measured by a potentiometer, a contact rotated by a synchronous motor and set to make contact at the max. value being used in measuring the a.c. voltages. Various shapes of electrodes were used, but most of the tests were carried out with spherical balls of Al and Cu of 1 cm. radius. Plane electrodes were also used, sparking from the edges being prevented by enclosing the metal faces in glass covers with circular openings of 1 cm. diam. The gap was enclosed in a tube with a quartz window through which the gap could be ionised by illumination from an arc lamp. Consistent results could not be obtained without illuminating the spark-gap. The gases used were N, H, and CO_2, carefully dried from 12 to 24 hours in a chamber containing P_2O_5. The following figures are extracted from the tables given :—

Spark-lengths in mm.	D.c. Volts	A.c. Max. Volts.	Remarks.
3·175	2915	3325	Cu spheres 1 cm. radius in hydrogen. Pressure 30 cm.
1·965	2060	2363	
0·827	1245	1464	
0·116	538	661	
6·47	3078	3341	Cu spheres 1 cm. radius in hydrogen. Pressure 15 cm.
4·185	2177	2375	
2·04	1283	1395	
0·45	538	649	
2·833	2785	3095	Cu spheres 1 cm. radius in nitrogen. Pressure 15 cm.
1·907	2105	2350	
0·916	1282	1374	
0·241	456	640	

The remaining test results are not tabulated in the paper, and as they are only given in curves without the reproduction of the squares of the squared paper it is not possible to abstract them fully or accurately. The following figures are selected to illustrate the main points of investigation. (The numbers after the word sphere in the table give the diam. of the sphere in cm.):—

Electrode.	Shape.	Gap, mm.	Gas.	Pressure, cm.	A.c. Max. Volts.	D.c. Volts.
Al	Sphere (1)	3	Air	15	3070	
Al	Plane	3	Air	15	2530	
Al	Sphere (1)	3	Air	10	2200	
Al	Plane	3	Air	10	1830	
Al	Plane	3	H	15	1910	
Al	Plane	3	H	10	1590	
Cu	Sphere (2)	3	H	30	3190	2800
Cu	Sphere (2)	3	H	15	1920	1730
Cu	Sphere (2)	3	CO_2	15	3220	2820
Cu	Sphere (2)	3	Air	15	3080	2650
Cu	Sphere (2)	3	N	15	3220	2970

If the a.c. and d.c. voltages corresponding to a given spark-length be compared, and the time calculated from the wave-form during which the a.c. potential is above the value required to produce a spark of the same length with direct current, the interval required to supply ionising energy to the dielectric is obtained. The result of applying this operation to a considerable number of tests gives an average time interval of 0·0024 sec., and this time does not appear to depend appreciably on the nature of the gap as regards gas, electrodes, or pressures. It has been stated by Merkel that there is a decrease of spark potential with increase of current density of discharge. An attempt to confirm this phenomenon failed, and its occurrence is attributed to resonance effects that were not eliminated in the experiments referred to.

A. J. M.

153. *Direct-current Corona for different Surfaces and Metals.* **S. J. Crooker.** (Phys. Rev. 8. pp. 344–363, Oct., 1916.)—The author has investigated the influence of the surface conditions of wires of different metals upon the starting-point and the characteristics of the corona discharge. The apparatus used consisted of a metal cylinder (inside diam. 3·63 cm.) with a longitudinal slot for observation (1·53 cm. wide), sealed in a glass cylinder, and so arranged that wires of different sizes could be easily strung along the cylinder axis. The voltage available consisted of forty 500-volt d.c. generators connected in series. Preliminary experiments were made with a steel wire of which the surface was polished over one-half its length and corroded with nitric acid over the other half. The characteristic negative beads appeared on the polished half, while on the other half there was a soft glow, different from the characteristic positive glow in that it was much greater in diam. and had a fuzzy appearance like goosedown. The first experiment led to the examination of a wire whose surface was not only (1) polished and (2) corroded, but also (3) mechanically abraded. In another experiment a German-silver wire was used, one half of its length being enamelled and the other half polished. Detailed tests were made on wires made of Cu, steel, Al, and Ag. Tables are given for the starting voltages, and characteristic curves are plotted. The results obtained cannot be usefully abstracted without reference to the photographs, tables, and curves.

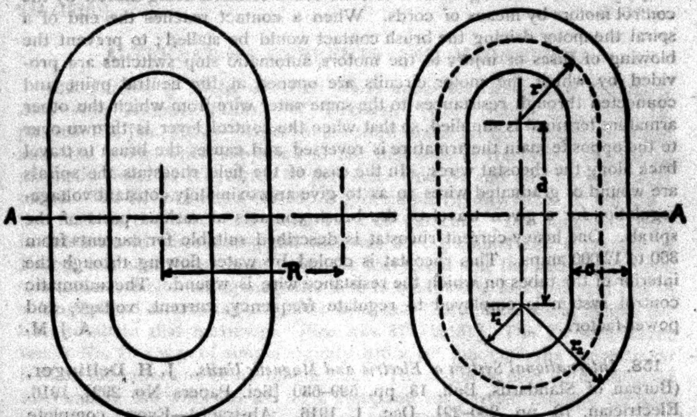
I. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

154. *Silver Voltameter.* **E. B. Rosa** and **G. W. Vinal.** (Bureau of Standards, Bull. 13. pp. 479–514 [Sci. Papers, No. 285], 1916.)—A summary of the experiments made on the silver voltameter at the Bureau of Standards, together with a very brief account of recent work done elsewhere. In 1911 at the Russian Bureau at Petrograd experiments by M. Foehringer with the Smith voltameter resulted in the value 1·01830 int. volts at 20° C. being assigned to the Weston normal cell. In 1916, Obata at Tōkyō, using the Smith voltameter, obtained the value 1·01827 int. volts at 20° C. A specification is proposed of which the main features are: (1) Pure electrolyte, the purity to be gauged (*a*) by a suitable chemical test, (*b*) by giving a crystalline deposit free from striations, and (*c*) by giving the same weight of deposit in a large and in a small voltameter. (2) The electrolyte to be neutral or slightly acid (say 1 part in 100,000). (3) Any septum which contaminates the electrolyte, or makes it basic, or produces more than a trace of acid must be avoided. Fairly complete instructions are given for the conduct of an experiment. In the opinion of the authors the most reliable forms of voltameters are the porous cup form, the Kohlrausch form, and the Smith form. These are in substantial agreement. As the paper is a summary of numerous experiments and results, it should be consulted by those interested. [See Abs. 1280 (1916).] F. E. S.

155. *Electrical Conduction in Metals at Low Temperatures.* **F. B. Silsbee.** (Washington Acad. Sci., J. 6. pp. 597–602, Oct. 19, 1916.)—In studying the experiments of K. Onnes on "super-conductivity" [see Abs. 1042, 1220 (1911)], the author has noticed a certain correlation between the phenomena of critical current density and critical magnetic field. When a superconductor is placed in a weak magnetic field it remains superconducting; as the field is increased, the normal resistance appears suddenly at a certain critical value of the magnetic field, and for still higher values of the field it increases slowly with the field. The critical value is slightly less when the field is transverse to the direction of current flow than when it is longitudinal, but the difference is not great. The author shows that the "threshold" value of the current is that at which the magnetic field due to the current itself is equal to the critical magnetic field; in other words the phenomenon of "threshold" current need not be regarded as a distinct phenomenon, to be explained by heating or otherwise, but is a direct result of the existence of the phenomenon of "threshold" magnetic field. The theories thus far proposed by Onnes, Lindemann, and Thomson to account for superconductivity do not specifically indicate the existence of a critical magnetic field, and only the latter (by assuming a saturation effect) accounts for a "threshold" current density. If it is true, as indicated by the author, that the magnetic effect is the more fundamental, it would seem that this fact might afford a valuable clue leading towards a more satisfactory theory of the super-conducting state and perhaps of metallic conduction in general. I. W.

156. *Variable Self and Mutual Inductor.* **H. B. Brooks** and **F. C. Weaver.** (Bureau of Standards, Bull. 13. pp. 569–580 [Sci. Papers, No. 290], 1916.)—The authors suggest the use of the name "inductor" for apparatus used to introduce "inductance" into a circuit, as well as "resistor" for apparatus possessing the property of "resistance." The paper describes the method of evolution and construction of an inductor having a range of variation of about 1 millihenry and a current-carrying capacity of about 5 amps. The form of apparatus considered to be most suitable is that consisting of two circular plates of ebonite, the lower plate containing two fixed coils, while the upper plate, containing two similar coils, can be turned about a central pivot carried by the lower plate. The requirements were: (i) High time-constant (ratio of inductance to resistance) for the space occupied by the instrument. This is based on the max. value of the inductance at the upper end of the useful part of the scale, and not on any greater value which is beyond the useful part of the scale. (ii) Large ratio of the max. inductance to the minimum inductance. Neither of these values must be outside the useful part of the scale. (iii) Astaticism. (iv) Linear scale. Requirement (ii) could only be fully met at the expense of (i), so that a balance had to be struck. Requirement (iv) was met by using elongated coils instead of circular ones. The effects of variation in the form of the coils, in the spacing of the coil groups, and in the angle between the longer axes of the coil and the line joining the centres of the coil groups were each investigated separately, a curve being determined for each case. While several arrangements were found which would give scales as uniform as those of other variable inductors in use, the advantages of a linear scale are so great that the work was continued until a compact arrangement of coils of simple geometric form and high time-constant was determined which gave this result as closely as physical limitations seemed to permit. The final form adopted was that shown in the Fig. with relative values as follows: $c = 0{\cdot}78r$, $d = 2{\cdot}2r$, $R = 2{\cdot}26r$, $r_1 = 0{\cdot}61r$, $r_2 = 1{\cdot}89r$. With these dimensions a linear scale is attained over the angular range from 80° to 150° movement from the initial position. An instrument with these dimensions was constructed for use at the Bureau, a full description illustrated with photographs being given in the paper. With the coils in series the resistance is 0·85 ohm and the time-constant for max. inductance setting is 8·4 milli-seconds. It is to be noted that a slight axial displacement of the movable disc will not affect the inductance, because the change caused by its movement away from one fixed disc is compensated by its approach towards the other. J. W. T. W.



157. *Remote Control in a Laboratory.* **P. G. Agnew, W. H. Stannard, and J. L. Fearing.** (Bureau of Standards, Bull. 13. pp. 581–597 [Sci. Papers, No. 291], 1916.)—A description of the construction and mode of operation of a remote control system in the electrical laboratory of the Bureau of Standards. Electric motors are installed to move contact brushes on the various resistances to be controlled, the switches controlling the different motors being mounted on movable control panels that can be connected to the motor circuits at different points in the laboratory by means of jacks. Each motor can be driven forwards or backwards at two speeds by connecting the armature between a neutral wire and either the positive or negative mains of a 2 × 120-volt supply or of a 2 × 10-volt battery, thus making coarse or fine control possible. The rheostats in the fields of the motors and generators supplying the testing currents are made in the form of spirals wound on long metal tubes, the brush contacts being moved by the control motors by means of cords. When a contact reaches the end of a spiral the motor driving the brush contact would be stalled; to prevent the blowing of fuses or injury to the motors, automatic stop switches are provided by which the motor circuits are opened at the neutral point and connected through resistances to the same outer wire from which the other armature terminal is supplied, so that when the control lever is thrown over to the opposite main the armature is reversed and causes the brush to travel back along the rheostat wires. In the case of the field rheostats the spirals are wound of graduated wires so as to give approximately constant voltage-regulation for a given travel of the brush contacts at various parts of the spirals. One heavy-current rheostat is described suitable for currents from 300 to 12,000 amps. This rheostat is cooled by water flowing through the interior of the tubes on which the resistance wire is wound. The automatic control system is employed to regulate frequency, current, voltage, and power-factor. A. J. M.

158. *International System of Electric and Magnetic Units.* **J. H. Dellinger.** (Bureau of Standards, Bull. 13. pp. 599–630 [Sci. Papers No. 292], 1916. Electrician, 78. pp. 290–291, Dec. 1, 1916. Abstract.)—Every complete system of electrical units requires four fundamental units, the need for an extra unit arising from the fact that the identity of mechanical and electrical phenomena has not been established. The international system is of the type which contains two electrical and two mechanical fundamental units, viz. ampere, ohm, centimetre, and second. One reason why the international system is the most used is because electric current is more familiar and of vastly greater practical importance than electrostatic charges or magnetic poles. Some of the advantages claimed for the international system are those of simplicity and the subordination of the magnetic pole; in the table of units and their dimensions magnetic pole strength is defined last, showing that all the other magnetic quantities are definable independently of it. The system is valuable, however, simply as a practical convenience in dealing with electrical phenomena. It is a common practice in electrical engineering in the United States to use the term "gauss" both for the unit of magnetic induction and the unit of magnetising force. This usage is encouraged by the fact of the numerical equality of B and H in non-magnetic media. Other confusing uses of the same unit for different quantities are the pound for weight and mass, and the kilogramme-metre, *e.g.* both for energy and torque. Similarly, the centimetre as a unit of inductance and of capacity is not entirely satisfactory. It is suggested that the term

gauss should be confined to the measurement of magnetic induction. There have been various proposals from time to time to rationalise the electric and magnetic units, that is, to use units which will redistribute the factor 4π in the equations. In no system is this factor entirely eliminated. The first proposal, that of Heaviside, had much to recommend it, but its general adoption now seems out of the question. A very satisfactory rationalisation is effected by the use of the ampere-turn as the unit of magnetomotive force, without recourse to new units. The ampere-turn systems of units proposed by Perry, Fessenden, Fleming, Giorgi, and Karapetoff are discussed, but no suggestion is made to discontinue the more common units. G. E. A.

159. *Remarks on Svedberg's Observations on Electrical Conductivity in Anisotropic Fluids.* **W. Voigt.** (Ann. d. Physik, 50. 2. pp. 222–228, June 15, 1916.)—A theoretical paper based upon the experimental work of Svedberg [Abs. 954 (1916)]. T. M. L.

ALTERNATING CURRENTS AND MAGNETISM.

160. *Fatigue of Nickel and Iron Wires under the Influence of Transverse Alternating Magnetic Fields.* **W. Brown.** (Roy. Dublin Soc., Proc. 15. pp. 168–170, Jan., 1917.)—Experiments were made on the fatigue of nickel and iron wires when subjected to the influence of transverse alternating magnetic fields of frequency 50 per sec. One Ni and one Fe wire were tested. The Ni wire was a No. 16 s.w.g. of simple rigidity 790×10^6 gm./cm.^{2}, the load on the lower end being $1{\cdot}5 \times 10^5$ gm./cm.^{2}. The magnetic field in the solenoid surrounding the wire was 20 c.g.s. units and a current of 1 amp. was sent through the wire. It was found that the max. fatigue due to a transverse alternating magnetic field is about 8·5 % less than that due to a longitudinal alternating magnetic field, and that it takes about double the time to attain that maximum. [See Abs. 877 (1916).] The Fe wire tested was a No. 16 s.w.g. of simple rigidity 810×10^6 gm./cm.^{2}, the longitudinal load on the lower end being 10^5 gm./cm.^{2}. The magnetic field in the solenoid surrounding the wire was 2·5 c.g.s. units, and the current through the wire tested was 1 amp. In the case of iron wire the max. fatigue due to transverse alternating magnetic fields is about 25 % less than the maximum obtained with longitudinal alternating magnetic fields of the same strength, and it takes about twice as long to attain the maximum. Experiment indicates that what is called fatigue and is measured by the magnetic twisting of the wire is not accompanied by any effect on the resistance. J. J. S.

161. *Manufacture and Testing of Prismatic Compasses.* **F. E. Smith.** (Electrician, 78. pp. 812–818, Dec. 8, 1916. Abstract of paper read before the Optical Soc.)—The object of the paper is to assist makers of the above instrument in its manufacture and in testing its reliability. The possible errors are summarised as follows: Want of parallelism of axis of magnet with the 180°–860° direction as indicated by the dial; eccentricity of dial and point of suspension; centre of suspension not in plane containing slit and line; want of uniformity of the engraved divisions on the dial; sighting line being out of the vertical when the compass is supported on a horizontal surface; prismatic effect of window and cover glasses; presence of magnetic material in the case, screws, etc.; faulty setting of prism in prism box; and excessive friction between pivot and jewel. For the methods involved in testing for these errors and also avoiding them the original paper should be consulted. G. E. A.

162. *Mechanical Relations of the Energy of Magnetisation.* **G. H. Livens.** (Roy. Soc., Proc. 93. pp. 20–27, Dec. 1, 1916.)—A mathematical paper. In the statical theory, the energy of magnetisation is usually made to appear as though distributed over the field with the density of $\mu H^2/8\pi$, which corresponds to an ethereal density of $H^2/8\pi$; but in the kinetic theory the same expressions are obtained with opposite signs. Several authors have tried to construct a more consistent theory on a new basis. In the present note, the author shows that it is possible to interpret the older and more usual form of the theory in a perfectly logical and consistent manner so that the discrepancy mentioned does not even present itself. G. E. A.

163. *A Mechanical Property of Magnetised Bodies.* **E. F. Northrup.** (Met. and Chem. Eng. 15. pp. 624–625, Dec. 1, 1916.)—On passing an alternating current through an impedance consisting of a horizontal solenoid with core of loosely packed iron wires the author observed that the wires were displaced parallel to the axis of the solenoid, forming a cone protruding at one end. This cone could be formed at will, at either end, it being only necessary to give the central wires a small displacement in the direction desired. If a thick sheet of iron be magnetised with a uniform distribution of north polar magnetism over one surface and south polar magnetism over the other, then a small cylinder of this substance whose axis is parallel to the direction of magnetisation would, if free to move, be in unstable equilibrium. On this principle the author has constructed a magnetic "jack-in-the-box." A piece of steel shafting is wound with a magnetising coil. A central hole is drilled through the shafting and fitted with a soft-iron rod. On passing a current round the coil the central rod is suddenly projected vertically up and stands on the upper end of the shaft. L. L.

164. *Corbino-effect.* **K. K. Smith.** (Phys. Rev. 8. pp. 402–411, Oct., 1916.)—If a circular metallic disc in which a radial current of electricity is flowing is brought into a magnetic field the paths of the electrical carriers are, in general, changed. Corbino first made such experiments upon a disc of Bi, and found that a magnetic field normal to the plane of the disc produces in it a steady circular current of electricity which reverses its direction on reversal of either the radial current or the magnetic field. He also observed that if the disc is suspended so that the lines of force are oblique to its plane, an electromagnetic torque tends to turn it about a vertical axis. The disc turns in the opposite direction when the radial current is reversed, but a reversal of the magnetic field does not change the sense of rotation. In the latter respect this torque differs from the electromagnetic forces of Ampère, which depend upon the sense of the magnetic field. Corbino, and afterwards Adams, deduced certain expressions for the values of the circular current and the torque; the former assumed that the current in a metal is carried by both positive and negative ions, while the latter assumed that it was carried by electrons only. Adams and Chapman measured the current in various metals and found variations both in sign and magnitude. In Bi the circular current has the same direction as the magnetising current when the radial current flows outwards from the centre; in Sb the circular current is about one-tenth as large, and is in the opposite direction. The former effect is called negative, the latter positive. On the theory that the current is carried wholly by electrons, the Corbino-effect, as well as the Hall-effect, should be negative in all metals. Both positive and negative effects are provided for in Corbino's theory, the sign being positive when E, the characteristic constant, is positive, *i.e.* when the mobility of the positive carriers exceeds that of the negative.

The author has determined the values of the constant E for Bi, Sb, Te, graphite, Ag, and W, by measuring the torques acting on discs. The method employed did not differ essentially from that originally used by Corbino. A table is given of the values of R (Hall-effect), ρ (specific resistance), R/ρ, and E for the substances mentioned above. While R and ρ vary over a large range for the different conductors, the range of variations of R/ρ is much more restricted, and the latter values are of the same order of magnitude as the corresponding Corbino coefficients, E. While the exact quantitative relation between R/ρ and E is not obvious, it can be seen from the table that the sign and order of magnitude of one effect can be predicted if the other is known. I. W.

165. *Lunar Distance and Magnetic Declination at Zi-Ka-Wei.* **S. Chapman.** (Terrest. Magn. 21. pp. 151–152, Sept., 1916.)—De Moidrey has found that the solar diurnal amplitude of magnetic declination at Zi-Ka-Wei varies in some relation to the moon's position, the mean ratio of the amplitudes at perigee and apogee being 1·028. It has been previously shown by Chapman that the lunar semidiurnal magnetic variation is larger at perigee than apogee with a ratio of 1·89. The present paper gives the result of an inquiry undertaken to examine whether the lunar diurnal variation, depending largely on the moon's distance, acting with a constant solar diurnal variation, is operative in producing the effect found at Zi-Ka-Wei. An apparently simple explanation giving a suggestive correct numerical result has to be rejected owing to the fact that the phase of the lunar semidiurnal variation at apogee or perigee is continually changing, relative to solar time, on account of the difference between the synodical and anomalistic months. This effect of lunar distance is too small to be ascribed to direct tidal action, but no satisfactory explanation is found at present. C. P. B.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

166. *Stereoscope for determining Distances Numerically.* **J. Lahousse.** (Rev. Élec. 26. pp. 339–342, Dec. 1, 1916.)—The apparatus, which has been constructed by the author and Chassard, offers the following advantages: it gives a stereoscopic view of the region examined; it indicates without any calculation the numerical value of the distances from the plate of the points required; it indicates the real distances reckoned parallel to the plate. One of the two photographs necessary for obtaining the stereoscopic effect is viewed directly; the other, by reflection in a small mirror. The principle of the apparatus is discussed in detail, and it is shown that by a lateral displacement of the head a pseudoscopic view is obtained. As the result of many experiments it has been found that 55 cm. is the best distance for the photographic plate from the antikathode and the stereoscopic apparatus is so built that the eyes of the observer occupy relatively to the photographs the same positions as the antikathode. An explanation is given of the manner in which the apparatus can be used for localising foreign bodies in a plane parallel to that of the photographs. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

167. *Linear Force of Growing Crystals.* **G. F. Becker** and **A. L. Day.** (J. of Geology, 24. pp. 313–338, May–June, 1916.)—In 1905 the authors showed by appropriate experimental evidence that a single crystal immersed in its own saturated solution and growing by reason of the potential supersaturation of the solution resulting from evaporation, will lift a weight placed upon it. This observation, the accuracy of which was denied by Bruhns and Mecklenburg in 1913, has now been repeated and must be regarded as accurate. T. H. P.

168. *Plasticity of Solid Crystals.* **O. Lehmann.** (Ann. d. Physik, 50. 5. pp. 555–599, July 25, 1916.)—In solid crystals, which can flow under sufficiently strong stresses, the conditions which prevail are similar to those which occur in liquid crystals. T. M. L.

169. *Black Phosphorus.* I. **A. Smits, G. Meyer,** and **R. P. Beck.** (K. Akad. Amsterdam, Proc. 18. 6. pp. 992–1007, 1916.)—Measurements of the vapour pressure of black phosphorus [see Bridgman Abs. 1745 (1914)] show that below 550° a very slow increase of pressure is manifest, this being undoubtedly a consequence partly of an internal transformation, just as was observed with the disturbed violet phosphorus. A little above 550° the pressure usually became constant fairly soon, and this constant value agrees moderately well with the pressure of violet phosphorus. With rise of temperature above 570° the vapour pressure of the black phosphorus increases considerably above that of the violet phosphorus. Black phosphorus melts at 587·5°, which is 2 deg. lower than the melting-point of the violet modification, the latter appearing, as was to be expected—at higher temperatures at least—as the stable modification. The transformations of these different forms of phosphorus are discussed. T. H. P.

170. *Chemically Active Modification of Hydrogen produced by Alpha-rays.* **W. Duane** and **G. L. Wendt.** (Phys. Rev. 7. pp. 689–691, June, 1916. Abstract of paper read before the Am. Phys. Soc., April, 1916.)—A 5-cm.^{3} bulb of pure hydrogen was acted on by the α-radiation from 35 millicuries of radium emanation. A decrease in volume resulted.

A stream of hydrogen passed through a larger bulb and exposed to the α-rays liberated sulphuretted hydrogen when passed over sulphur, but this effect was reduced almost to nothing when the time elapsing after irradiation was increased to a minute.

The active hydrogen also attacks phosphorus with liberation of phosphine, and arsenic with liberation of arsine.

Neutral potassium permanganate solution was reduced to manganese dioxide, but indigo carmine and methyl violet were not reduced.

Exposure to liquid air after ionisation removed the activity. T. M. L.

171. *Constitution and Fundamental Properties of Solids and Liquids.* Part I. *Solids.* **I. Langmuir.** (Am. Chem. Soc., J. 38. pp. 2221–2295, Nov., 1916.)—The author outlines a theory of the mechanism of evaporation, condensation, liquefaction, adsorption, and capillary phenomena based on new and more

definite conceptions as to the nature of chemical forces deduced from the structure of crystals as found by W. H. and W. L. Bragg. The work of the latter authors is reviewed from the chemical standpoint and its relation to theories of chemical constitution, such as those of Werner, Stark, J. J. Thomson, and Lewis, is discussed in detail. It is concluded that the substances the structures of which have as yet been studied by the X-ray spectrograph are not representative of compounds in general, only polar compounds having been investigated. Solid polar compounds are, in general, built up of atoms bound together by secondary or residual valencies, and the whole crystal must be regarded as a single molecule. Solid non-polar compounds consist, in general, of "group molecules" in which the atoms are usually held together by primary valencies; these group molecules in turn are bound together by secondary valencies to form a large "crystal molecule," which includes the whole solid mass. There is no present justification for dividing interatomic (or intermolecular) forces into physical and chemical forces, and it is much more profitable to consider all such forces as strictly chemical in nature. Evaporation, condensation, solution, crystallisation, adsorption, surface tension, etc., should all be regarded as typical chemical phenomena, and the author attempts to show that chemical knowledge already available is directly applicable to the study of these phenomena. From a consideration of such properties as specific heat, compressibility, coefficient of expansion, etc., it is concluded that collisions do not take place between the atoms of solids, but that these move about equilibrium positions under the influence of both attractive and repulsive forces.

The "time of relaxation" of the atoms of solids is calculated approximately from the heat conductivity and is found to be of the order 10^{-14} to 10^{-7} sec.; an independent method, by which the "time of relaxation" may be calculated from the rate of evaporation of a substance in a vacuum, gives substantially similar results. Thus the time necessary for an atom of a solid to reach thermal equilibrium with its neighbours is very small compared with the time necessary for a single oscillation about an equilibrium position; the oscillations are, therefore, extremely damped.

Since solid substances in general are held together by secondary rather than primary valencies, there are few limitations to the number of compounds that can exist in the solid state, and most of these compounds do not show compositions which could be predicted from the ordinary rules of valency; metallic compounds, minerals, solid solutions, and glasses are discussed from this point of view. From considerations based largely on the compressibility, it is concluded that the attractive forces between atoms usually reach a max. intensity when the distance between adjacent atoms in solids is increased by about $0{\cdot}6 \times 10^{-8}$ cm. (10 to 30 % of the normal distance between atoms).

Since energy must be expended in breaking apart a solid, the surfaces of solids must contain more potential energy than do the corresponding number of atoms in the interior, and as this potential energy is probably electromagnetic energy in the field between atoms, the interatomic forces are more intense on the surface than in the interior; this intense surface field of force (unsaturated chemical affinity) is one of the causes of the phenomena of condensation and adsorption. Because of the small time of relaxation and because an atom approaching the surface is attracted by many but is later repelled by few atoms, it follows that the surfaces of solids are almost wholly inelastic in regard to collisions of molecules impinging on the surface; there is a great deal of experimental evidence of this inelasticity. As a result, nearly every molecule or atom striking a solid surface condenses, no matter what the temperature, and while condensed it is held to the surface by forces quite similar to those holding solids together (primary and secondary valencies). At high temperatures evaporation may take place almost immediately after condensation, but at lower temperatures the condensed atom or molecule may remain indefinitely. The phenomena of condensation and evaporation (sublimation) of solids are discussed at length. In general the rate of evaporation (m) of a substance in a high vacuum is related to the pressure (p) of the saturated vapour according to the expression $m = (M/2\pi RT)^{1/2}p$; red phosphorus and certain other substances probably form exceptions to this rule.

The mechanism of the dissociation of a solid, such as calcium carbonate, is discussed, and it is shown that when, according to the phase rule, separate phases of constant composition are present, the reaction must take place exclusively at the boundaries of these phases. This kinetic interpretation of the phase rule indicates clearly the distinction between reactions in which solid solutions are formed and those in which separate phases appear. This theory affords a ready explanation of the fact that hydrated crystals frequently fail to effloresce unless scratched and for the fact that thoroughly dehydrated substances often absorb moisture with great difficulty.

Adsorption is a direct consequence of the time lag between the condensation and the subsequent evaporation of molecules. A large number of experimental results are given which prove conclusively that adsorption is very frequently the result of the strongest kind of chemical union (primary valency) between the atoms of the adsorbed substance and the atoms of the solid.

It is shown that the action of a typical catalytic poison depends on the formation of a very stable film one atom deep over the surface of the catalyst. The chemical activity of any solid surface depends upon the nature, arrangement, and spacing of the atoms forming the surface layer. A very intimate relation exists between the chemical activity of a surface and the emission of electrons from it (either thermionic or electric emission).

A brief quantitative development of this theory of heterogeneous reactions is given. A law of surface action, analogous to but different from the law of mass action, is proposed. The theory is in accord with and affords an explanation of Reichinstein's "Constant Sum Hypothesis." An outline is given of the application of the theory to heterogeneous gas reactions and to enzyme action. T. H. P.

172. *Flame-arc in Chemical Manufacture.* **W. R. Mott** and **C. W. Bedford.** (Ind. and Eng. Chem., J. 8. pp. 1029–1035, Nov., 1916. El. World, 68. p. 1302, Dec. 30, 1916.)—Photochemical action depends upon light-absorption, and as chlorine and bromine absorb blue and green rays, whilst they are transparent to ultra-violet rays, short visible rays are most active for chlorination. The authors find that the flame-arc of high amperage is, in proportion to the current used, the most efficient source of light for some photo-chemical reactions. The action of the d.c. white arc on sensitised paper is approximately expressible by $KC^{1{\cdot}8}(V-28)$, where K has the value 0·0085 and C and V denote amps. and volts. The white flame-arc is rich in blue rays; the composition of the carbons is kept secret, but it is known that rare earths are used. The white flame-arc is better suited for glass vessels than for quartz vessels; its effect on sensitised paper of p-phenylenediamine is three times stronger than that of coloured-flame carbons. The light and the chemical

power increase as the volts are raised; but the rate of increase diminishes at high values. The white flame-arc is superior to the enclosed-arc lamp; with the help of a shunt round the resistance and a solenoid on d.c. circuits, or of a reactance coil in shunt to the lamp reactance coil and solenoid on alternating circuits, the enclosed arc may be modified for the use of flame carbons; the arrangements are illustrated. Particulars are given of chlorination experiments made with a flame-arc (25 amps., 45 volts) and a mercury-vapour quartz lamp of Heraeus (using Aaron's amalgam at 4 amps. and 220 volts); the exposures required were much shorter with the flame-arc.

H. B.

173. *Elastic Limit of Steel.* **N. I. Belaiew and N. T. Goudtsow.** (Rev. de la Soc. russe de Mét. 1. pp. 382–414, 1914. Rev. de Mét. 13. pp. 116–148, March–April, 1916.)—An ingot of acid open-hearth steel of the composition 0·34 % C, 0·60 % Mn, 0·26 % Si, 0·036 % S, and 0·034 % P was cropped top and bottom and had its centre removed by boring so as to leave the remainder as homogeneous as possible. The annular section was then cut into four parts and the largest portion machined into bars of 32 mm. in diam. The other portions were hammered into round bars of the same diam. Thermal examination of the steel showed that the critical points were situated at 735° C. on heating, and at 735° and 690° on cooling. Mechanical tests were made on the bars after various forms of heat treatment. Three different testing machines were used in making the test, and the proportional limits were determined by three different types of apparatus so as to make the results as independent as possible of the methods of testing. In the tests made on unforged material it was observed that the values of the max. stress and the yield-point did not differ materially when determined by different methods. The proportional limit, however, showed considerably greater variations: these variations were found to increase with the temperature of annealing. The results show that when care is taken to maintain uniform conditions, variations between 1100° and 850° C. in the temperature of annealing produce no marked effects on the mechanical properties of a steel of medium carbon-content. Progressive lowering of the temperature from 850° to 740° in the annealing operation diminishes the tensile strength and increases the elongation and the reduction of area. Microscopic examination indicates that this is due to the transformation of the agglomerations of lamellar pearlite into sorbitic pearlite. The ratio between the apparent limit of elasticity (yield-point) and the proportional limit of elasticity is constant, the curves showing these values as functions of the annealing temperatures being parallel. The effects of reheating after quenching the bars from 760° C. was next studied. By increasing the tempering temperature of a quenched steel it is possible to restore the original properties of the steel. A steel which had been quenched and reheated at 740° C. had almost identical properties with the steel annealed at 740°. The reduction of area attains a maximum in the steel reheated at 650°. As the temperature of reheating is increased, the max. stress, the proportional limit and the yield-point decrease. Plotted as functions of the reheating temperature the two latter values give curves which are parallel. At the same time, however, th
two values determined by different methods show greater variation
themselves as the temperature of reheating decreases. Similar
obtained with a 0·42 % C steel. N. E.

Consideration of all the results leads the auth2310–2316, Nov., 191
it is necessary to distinguish two methods of gard to the relative extents

above 850° C. which confers a granular structure on the metal, increases its max. stress, and decreases the reduction of area; and (2) annealing at a temperature of 740° C., which renders the structure more homogeneous, slightly lowers the max. stress and considerably increases the reduction of the area. The max. stress, the proportional limit, and the yield-point can only be varied to any extent by quenching followed by tempering, and from the point of view of the static tests 650° appears to be the best tempering temperature; but the fact of 740° being the best temperature of annealing and 650° being the best temperature for reheating from the practical point of view, can only be settled by a series of fatigue tests made on the same samples, and this the authors propose to do at some future date. Tests made to show the influence of lack of homogeneity caused either by internal stresses set up by lack of uniformity in mechanical or thermal treatment, indicate that the greater the heterogeneity the lower the values of the elastic limits. Determination of the mechanical properties and examination of the microstructure of a eutectoid steel after an annealing at 1000° and 740° showed that such a steel only acquires normal properties when the lamellar pearlite is changed to granular pearlite. This confirms and extends the principle outlined above, viz. that the greater mechanical and physical heterogeneity of the steel the lower the values of the proportional limit and the yield-point. Further, the proportional limit is affected to a greater extent than the yield-point. From a general consideration of their own work and that of previous investigators the authors conclude that the proportional limit is a measure of treatment to which the specimen has been subjected and of the conditions of the test, rather than of the properties of the material itself. The relative values of the proportional limit and the yield-point determine the degree of heterogeneity of the material under test. Since, therefore, the proportional limit is affected by external influence, it is liable to give a false idea of the properties of the material under test and from the commercial-testing point of view the most satisfactory method is to determine the autographic stress-strain diagram. F. C. A. H. L.

174. *Influence of the Time of Heating prior to Quenching on the Results of that Operation.* **A. Portevin.** (Rev. de Mét. 13. pp. 9–78, Jan.–Feb., 1916.)—In the operation of hardening steels there are three periods, namely: (1) In which the temperature is rising, (2) during which the temperature remains constant at some value above the critical temperature, and (3) during which the temperature is falling rapidly, *i.e.* the quenching period. While a number of workers have made a study of the last period, the study of the first two periods has been neglected, and the author has carried out numerous tests to fill this gap in our knowledge. Preliminary tests were made to determine the relations existing between the diam. of the specimen, the times taken to attain various temperatures, and the temperature of the salt-bath in which heating was carried out. Experiments were then carried out on the effects of heating, for different times at temperatures between 800° and 950° C., on the mechanical properties, hardness, resilience, and the electrical resistance of steels of varying carbon-content, and also of chrome, tungsten, and molybdenum steels. The study was extended by microscopic analysis. Because of experimental difficulties, the results show errors, many of which are inexplicable, but in a general way they indicate that the properties of a quenched steel depend not only on the temperature to which it was heated prior to quenching, but also upon the time it was maintained at the temperature. Attention is drawn to the futility in industrial operations of using a sensitive pyrometer to indicate the temperature of the furnace or of the surface of the metal undergoing treatment without having any definite information as to when the metal is uniformly heated throughout its mass. Some difficulties arising in the applications of the Fourier law of heating to the cases of metals are discussed and a calorimeteric method of determining the total time of heating in a gas furnace is described in appendices to the paper. The decarburising effect of heating in a fused alkali-chloride bath has been confirmed. The addition of cyanides to the bath does not prevent decarburation although the cyanide-chloride bath will carbonise soft iron. F. C. A. H. L.

175. *Diffusion Cells in Ionised Gases.* **E. B. Wood, O. A. de Long, and K. T. Compton.** (Phil. Mag. 32. pp. 499–504, Nov., 1916.)—It has been shown by Jenkinson [Abs. 140 (1915)] that an e.m.f. is set up between two similar electrodes in a gas if the degree of ionisation of the surrounding gas is not the same at the two electrodes. The explanation given by Jenkinson of his results seems improbable, and the authors advance an interpretation which involves neither the formation of an occluded gas layer nor the passage of electricity to and from a metal by the sole agency of positive ions.

The simplest case is that of two infinite parallel metal plates and a source of ionising radiations which ionises the intervening gas more strongly near one plate than near the other. If the two plates are originally at the same potential, the ions will move by diffusion from the regions of greater to those of less concentration, but this process will never produce uniform ionic concentration in all parts of the gas because of recombinations which take place simultaneously with diffusion; in this respect the present case differs from the similar case of an electrolyte. If the positive and negative ions diffuse at the same rate the plates will obviously remain at equal potentials; if, however, as is usually the case, the negative ions diffuse at a more rapid rate than the positive ions, the plate in the region of less ionic concentration will acquire a negative charge and a negative potential with respect to the other plate. If the plates are insulated, this process will continue until the electric field is just sufficient to cause the positive and negative ions to drift at equal average rates towards the negative plate, numbers of them recombining as they drift.

That this is the correct explanation is shown by various experiments.

T. H. P.

176. *Application of the Theory of Allotropy to Electromotive Equilibria.* **A. Smits and A. H. W. Aten.** (K. Akad. Amsterdam, Proc. 19. pp. 133–148, 1916.)—In their previous paper [see Abs. 958 (1916)] the authors introduced a new method of regarding electromotive equilibria, based on the assumption that the electrons in a metal phase and in the co-existing electrolyte behave as ions. The equilibrium between metal and electrolyte is now considered (1) in the case when the metal consists of atoms, polyvalent metal ions and electrons, and (2) when in the metal there are present metal ions of different valencies, as well as atoms and electrons. Polarisation and passivity of the metal in these two cases are discussed. T. H. P.

177. *Tenth-Normal Hydrochloric Acid Calomel Electrode.* **N. E. Loomis and M. R. Meacham.** (Am. Chem. Soc., J. 38. pp. 2310–2316, Nov., 1916.)—In order to remove the uncertainty existing in regard to the relative extents

of dissociation of decinormal hydrochloric acid and potassium chloride, the authors have made careful measurements at 25° of the e.m.f. of the system, H_2—Pt—0·1N·HCl—Hg_2Cl_2—Hg, the result obtained being 0·3988 ± 0·0002 volt. The variations observed in the e.m.f. are larger than would seem warranted in the measurement of a system involving only very small contact potentials and the only regularity observable in these variations is a general tendency for the potential of the calomel electrode to increase on standing. It seems probable that some chemical change, such as that of the calomel to mercuric chloride, occurs in the system. The 0·1-N hydrochloric acid calomel electrode is, therefore, not nearly so constant and reproducible as the 0·1-N potassium chloride calomel electrode. Within the limits of experimental error—probably within 1 %—hydrochloric acid and potassium chloride are equally dissociated at decimal concentrations.

T. H. P.

178. *Influence of the Potassium Ion and of the Calcium Ion upon the Ferri-ferro-cyanide Potential.* **E. P. Schoch** and **W. A. Felsing.** (Am. Chem. Soc., J. 38. pp. 1928–1947, Oct., 1916.)—In order to gain further insight into the concentration relations in ferri-ferro-cyanide mixtures [compare Abs. 741 (1909)] the authors prepared two series of mixtures and measured their specific conductivities and their potentials against a normal calomel electrode. In one series, the mixtures contained only potassium ferricyanide and potassium ferrocyanide, whilst in the other series the mixtures contained potassium chloride in addition to these salts. The conductivities of these mixtures were in very good agreement with the results calculated by means of the rule of mixtures. Similar measurements were made on mixtures of the calcium salts of the above acids and gave a good agreement between the observed and calculated results. The constituent ions and un-ionised molecules in all these mixtures were calculated on the assumption that intermediate ions are absent, and the following empirical formulæ were found to represent the dependence of the potentials upon the constituents of the mixtures through a potassium ion ($K^{\cdot}$) range of 10 to 400 milli-equivalents per litre, and a calcium ion ($Ca^{\cdot\cdot}$) range of 3 to 80 milli-equivalents per litre. In the formulæ, E represents the observed potential at 25°, $[FeC_6N_6''']$ the concentration of the ferricyanide ion, and $[K_3FeC_6N_6]$ the concentration of the *undissociated* potassium ferricyanide; similarly for the ferrocyanide salts.

$E = E_{k_1} + 0{\cdot}0591 \log [FeC_6N_6'''][K^{\cdot}]^{0{\cdot}75}/[FeC_6N_6'''']$, where $E_{k_1} = +0{\cdot}0526$ volt, the max. variation in E_{k_1} being 4·3 millivolts.

$E = E_{k_2} + 0{\cdot}0591 \log [K_3FeC_6N_6][K^{\cdot}]^{0{\cdot}675}/[K_4FeC_6N_6]$, where $E_{k_2} = +0{\cdot}0758$ volt, the max. variation in E_{k_2} being 6 millivolts.

$E = E_{k_3} + 0{\cdot}0591 \log [FeC_6N_6'''][Ca^{\cdot\cdot}]^{0{\cdot}625}/[FeC_6N_6'''']$, where $E_{k_3} = +0{\cdot}0916$ volt, the max. variation in E_{k_3} being 1·7 millivolts.

$E = E_{k_4} + 0{\cdot}0591 \log [Ca_3(FeC_6N_6)_2][Ca^{\cdot\cdot}]^{0{\cdot}675}/[Ca_2FeC_6N_6]$, where $E_{k_4} = +0{\cdot}1415$ volt, the max. variation in E_{k_4} being 4·1 millivolts.

Details are given of a new method of deriving significant values of *n* and *k* in the formula: $C_i^n/C_u = k$, for such salts as ferricyanides and ferrocyanides, for which these values vary greatly with the concentration. T. S. P.

179. *Overvoltage Tables.* I. *Kathodic Overvoltages.* II. *Anodic Overvoltages.* **E. Newbery.** (Chem. Soc., Trans. 109. pp. 1051–1066, and 1066–1078, Oct., 1916.)—Part I.—Nearly all the data available which deal with the subject of overvoltage relate to that of metals in various solutions under the action of a current too small to be of any practical value to the chemist. The present work was undertaken with the object of supplying data whereby some idea of the best conditions for obtaining suitable overvoltages and keeping these constant where possible, under conditions of current suitable to the chemist, may be gained. When working with normal sulphuric acid solutions a mercurous sulphate electrode was used for measuring the kathodic overvoltage, whilst with normal sodium hydroxide solution a mercuric oxide electrode was used. For each metal used as kathode, two different sets of experiments were made. In the one set the overvoltage was measured after a given current had passed for one minute; the current was then increased and the overvoltage measured again after one minute, and so on; the current densities varied from 2 to 2000 milliamps. per cm.^{2}. In the other set the overvoltage for a given current was read at varying intervals of time up to a period of 30 minutes; the current was then raised and the measurements repeated after the surface of the electrode had been renewed; the current densities varied from 1 to 1000 milliamps. per cm.^{2}. The substances used as electrodes were: Au, Pt, Cu, Ag, Pb, Zn, Ni, Co, Sn, Al, Hg, and amalgamated surfaces of Cu, Zn and Pb, W, Sb, Bi, rods of electric light carbon and artificial graphite, pure iron, carbon steel, chrome steel, "tantiron," and silvered copper and nickel. The results of the measurements are given in detail, and are discussed from the chemist's point of view in connection with electrolytic reduction.

Part II.—A similar set of experiments to those described in Part I, the anodic overvoltages being measured. In addition to the metals there mentioned the behaviours of Mg, Mn, and Ir were investigated. Amalgamated and alloyed electrodes were not used. T. S. P.

180. *Overvoltage Tables.* III. *Overvoltage and the Periodic Law.* E. **Newbery.** (Chem. Soc., Trans. 109. pp. 1107–1117, Nov., 1916.)—An examination of the results hitherto obtained [see preceding Abs.] showed that the kathodic overvoltage of a metal is closely connected with its position in the periodic system. In order to examine this phenomenon still further it was necessary to determine the overvoltage of as many metals as possible. The overvoltages of the following ten metals, in addition to those previously examined, have therefore been determined: Mg, Cd, Tl, Ta, Cr, Mo, Mn, Rh, Pd, and Ir. The results obtained are discussed critically and the following table is given to show the distribution of the metals in the groups according to their kathodic overvoltages; those which have the overvoltage of a group to which they do not properly belong are placed in brackets.

Group 0. Typical overvoltage, 0·0 volt. (Ag), (Hg), (Al), (Bi), (Ni), (Rh), (Pd), (Ir), (Pt).
Group I. Typical overvoltage, 0·35 volt. Na, Cu, Ag, Au.
Group II. Typical overvoltage, 0·70 volt. Mg, Zn, Cd, Hg, (C), (Sn), (Pb), (Sb), (Bi), (Mn), (Co), (Pd), (Ir), (Pt).
Group III. Typical overvoltage, 0·50 volt. Al, Tl, (Sb), (Ta), (Bi).
Group IV. Typical overvoltage, 0·45 volt. C, Sn, Pb, (Ir), (Pt).
Group V. Typical overvoltage, 0·42 volt. Sb, Ta, Bi, (Cr).
Group VI. Typical overvoltage, 0·32 volt. Cr, Mo, W, (Fe), (Ni).
Group VII. Typical overvoltage, 0·25 volt. Mn, (Fe), (Ni), (Co), (Pd), (Pt).
Group VIII. Typical overvoltage, 0·18 volt. Fe, Ni, Rh, Ir, Pt.

The only metals in this table which do not appear in their proper groups are Co and Pd. Where metals have overvoltages corresponding with more than one group, compounds of these metals are known in nearly all cases in which the metal shows a valency corresponding with that of the other metals of the groups with which it is placed.

The anodic overvoltages of metals in the periodic groups do not show the same degree of regularity as the kathodic overvoltages. There are two main reasons for this, namely: (1) the impossibility of obtaining an aqueous electrolyte having only one anion, whereas any dilute acid gives a single kathion; (2) in most cases fairly stable oxides or peroxides are formed, and some of these are poor electrical conductors. A partly insulating film then forms on the electrode surface and gives rise to abnormally high values for the anodic overvoltage. T. S. P.

181. *Electrolytic Oxidation of Sulphur Dioxide.* **M. de K. Thompson and N. J. Thompson.** (Met. and Chem. Eng. 15. pp. 677–679, Dec. 15, 1916.)—A current of SO_2 (from heated sulphuric acid and copper wire) is passed into the anode compartment (porous cup, 15 cm. high, 5 cm. diam.), entering underneath the anode of sheet Pt; the kathode, a nickel cylinder, surrounds the cup. Both compartments are filled with sulphuric acid, and the whole cell is cooled so that the temperatures of the anode and kathode compartments are at about 25° and 20° C. The current density was varied from 0·19 to 0·50 amp./cm.^{2} and the concentration of the sulphuric acid was also varied from 10 up to 98·5 %. The total amount of current used was determined by means of a copper coulombmeter, and the current efficiency was estimated by measuring the volume of oxygen (counted as lost) escaping from the anode compartment; before each run all oxygen was removed from the apparatus by passing SO_2 through it for an hour. The efficiency curves obtained are regular. The efficiency of the electrolytic oxidation of SO_2 to sulphuric was high, but decreased with increasing current density and dropped off noticeably, finally rapidly, as the concentration of the sulphuric acid increased above 80 %. The research was undertaken in connection with experiments on the extraction of copper from ores. H. B.

182. *Significance of Ionic Migration Experiments.* **S. W. J. Smith.** (Phys. Soc., Proc. 28. pp. 316–329, Aug. 15, 1916.)—In order to explain the discrepancy between values for the migration constant of copper sulphate as determined by Hittorf and by C. H. Griffiths [Abs. 839 (1916)] the conditions affecting the experiment are analysed in detail, including such factors as the displacement of liquid from the kathode chamber by the copper deposited on the kathode, and the shrinkage which results from the removal by electrolysis of copper sulphate from the solution surrounding the kathode. The conclusion is drawn that the conditions were less favourable in the new than in the old determinations. The influence of hydration on ionic migration-constants is also discussed. T. M. L.

183. *Measurement of Electrolytic Conductivity.* I. *Theory of the Design of Conductivity Cells.* **E. W. Washburn.** (Am. Chem. Soc., J. 38. pp. 2431–2460, Nov., 1916.)—The author discusses the theory of the design of conductivity cells and gives drawings of a series of cells covering the whole range of conductances from 1 to 10^{-7} reciprocal ohms, *i.e.* from conductivity-water up to the strongest solutions. T. M. L.